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A COMPARATIVE SENSORY ANALYSIS OF HELEN KELLER AND LAURA BRIDGMAN.*†‡

II. Its Bearing On the Further Development of the Human Brain.

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It was my special problem in considering Helen Keller's sensory equipment to estimate as accurately as possible the value of the several senses contributing to her sensorium by which she gained an impression of her total environment. From her nineteenth month, she was blind and deaf. Her sense of smell, however, has been preserved and is of actual value to her in making contacts with the world. Her sense of taste is likewise preserved. It is, however, of much less value than the sense of smell but has not been without its benefits in her development. Being totally deprived of her intermediate contact sense, she depends primarily on her sense of touch. Her skeletal and visceral senses are well developed.

A comparison between Helen Keller and Laura Bridgman has important bearing. Miss Bridgman was even more limited as to her sensory avenues than Miss Keller. She lived to be about 60 years of age. During infancy she suffered from severe convulsions. In her twenty-fourth month she had scarlet fever. Two older sisters died of the disease. Lauras' eyes and ears suppurated, and sight as well as hearing was destroyed. Smell and taste were so nearly destroyed that

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both of these were almost useless to her during the greater part of her life. It is questionable whether at any time she had olfactory sense. Thus, Laura Bridgman made her adjustment to life with but one of the possible contact senses, namely, the sense of touch. Helen Keller, on the contrary, had the advantage of olfactory sensation and also somewhat of the sense of taste. The latter sensory avenue failed to open up much of the world to Miss Keller, but the sense of smell has proved to be of considerable importance in her intellectual development.

A brief history will suffice to establish Miss Keller's clinical background.

She was born, June 27, 1880, in Tuscumbia, a little town of northern Alabama. Her father's ancestry was Swiss. One of these Swiss ancestors was the first teacher of the deaf in Zurich and wrote a book on the subject of their education. Her mother was an Everett, belonging to the same family of Everetts as Edward Everett and Edward Everett Hale.

She was born healthy and remained so until in her nineteenth month, when she suffered from what was called "an acute congestion of the stomach and brain" which deprived her of sight and hearing. She had learned to say a few words, but these were soon entirely forgotten. And so as a result of her illness she became deaf, blind and dumb. When she was 6 years old, Dr. Alexander Graham Bell advised her father to write to the Perkins Institute for the Blind in Boston, and ask for a competent teacher. In March, 1887, Miss Sullivan, now Mrs. Macy, came to Helen in the beginning of her seventh year. Of this momentous event, Miss Keller writes: "Thus I came out of Egypt and stood before Sinai and a power divine touched my spirit and gave it light so that I beheld many wonders, and from the sacred mountain I heard a voice which said 'Knowledge is love and light and vision.'"

The truly marvelous results of education which Miss Keller has now made a matter of history were due to the ingenuity and wisdom of her teacher, Mrs. Macy, under whose tutelage she prepared for and entered Radcliffe College in the fall of 1900. She graduated with honors, and since that time her writings, her addresses and her efforts in behalf of those afflicted as she has been are among the notable achievements of modern civilization.

ANALYSIS OF HELEN KELLER'S SENSORY EQUIPMENT.

To evaluate Miss Keller's sensory equipment, it is necessary to discuss each one of her senses separately. This discussion has as its main object a comparative study with presumably normal adults of approximately the same age as Miss Keller. For the purpose of making such comparison, it was necessary to establish certain means for measuring sensation in order that the measurements in the normal group might be compared with those of Miss Keller. In consequence, it was thought advisable to devise certain new instruments or to provide the application of certain modes of sensory stimulation the degree of intensity or volume of which was measurable.

So far as possible, the tests applied in this study were metrical, and the figures obtained as a result of such measurements were made the basis of comparison. In dealing with each sensory component, two aspects of its sensory avenue were considered: 1. what may be called the subjective phase, or what the subject reports concerning this sense irrespective of the application of any tests; 2. the objective phase, revealing what the subject reports as a result of special tests devised to stimulate this sensory pathway.

The Sense of Smell: Beginning with Miss Keller's olfactory sense, the anatomic substratum of which is the first or olfactory cranial nerve, with its territories in the brain making up the rhinencephalon, the following facts have been brought to light: Miss Keller has an extremely sensitive olfactory sense. I may recite in this connection my experience with her in a drive from her home in Forest Hills to Garden City, a distance of about 20 miles. The windows of the car were open. It was a fresh, crispy day in winter. I asked Miss Helen if she could tell me anything about the country through which we were passing, and her first observation was that we were then making our way through open fields. This proved to be the case, for the road ran through a golf course. Later, she said that we were passing trees. The road at this point made its way through a small grove. She then called attention to the fact that we had just passed a house with an open fire, and looking back I saw a small cottage with smoke pouring out of its chimney. She recognized at once when we turned off the main road to enter the Motor Parkway, and in the course of our drive along this road she declared that we were then passing a number of large buildings; looking behind me, I saw that we were actually in the vicinity of the several groups of structures constituting the Creedmore State Hospital for the Insane. In the course of our conversation concerning her olfactory sensitiveness, I asked Miss Keller if she would write out for me how important the sense of smell had been to her life and development. Shortly after this Miss Keller called attention to the fact that we had just entered Garden City and were passing the plant of Doubleday and Doran, her publishers, which actually was the case. Her realization of this fact, she told me, was due to her olfactory recognition of the ink from the presses of this publishing establishment with which she was familiar. In response to my request for some statement concerning her olfactory sense, Miss Keller wrote on the typewriter the following letter addressed to me, which is transcribed in full, not only as bearing on the point in question, but as showing the remarkable content of Miss Keller's mind, her literary appreciation, her phenomenal memory and her mastery of literature.

Forest Hills, L. I., N. Y., Feb. 8, 1928.

Dear Dr. Tilney:—Since our conversation last Saturday with regard to the importance of odors and vibrations in my life, I have remembered that I went into it quite fully in "The World I Live In". I asked Mrs. Henney to send you the book. You probably have it by now.

The sense of smell is the esthetic sense, I think, even more than sight. I know that odors give me a vivid conception of my surroundings. I call smell my landscape because, when I walk or drive through the country, so many odors tell me of fields, streams, honey-sweet valleys and hillsides covered with pines. If, as we are told, the ten thousand Greeks "shouted for joy when they saw the sea," I can imagine there must have been still more rejoicing when its bracing breath filled their nostrils.

How many memories, sad and bright, odors awaken in one's heart! Instantly a scent will carry one back through the years to a forgotten experience. A correspondent who had been with the "Princess Pat's Regiment" in France told me that once, after his return to America, the scent of trodden grass caused him to faint, so forcibly had it brought to him the memory of being wounded, and lying with face downward on blood-soaked grass!

I am very sensitive to unpleasant odors. They have a depressing influence upon me; for they suggest all manner of dread things—disease, accidents, coming evil and unhappy lives. Sometimes, when such an odor comes between me and a beloved object, a nervous tremor seizes me, and I find it difficult to control myself. In my reading I have found that the Russians and the French are very sensitive to the odors which bring me delight and pain. Shakespeare, too, is full of references to the olfactory sense. A number of passages occur to me which I will note: In the scene where Hamlet stands by the grave of Ophelia, and holds out the jester's skull to Horatio, he asks in effect, "Did not Alexander, think you, look like this on earth?" Horatio replies, "Even so," and Hamlet asks, "and smelt so?"

In "Macbeth," after the murder of Duncan, Lady Macbeth, gazing on her soft white hands, cries, "Out, damned spot! Out, I say. . . . Here's the smell of blood still; all the perfumes of Arabia will not sweeten this little hand." The smell-sensation, you see, is emphasized more than the sight of the blood-stain.

Juliet tells us

"that which we call a rose

Would by any other name swell as sweet."

Obviously, she is more impressed by the sweet smell of the rose than by its rich color or its exquisite petals.

When Juliet wonders what will become of her if she wakes in the tomb before Romeo comes, the odor-sense is skillfully employed to darken the picture:

"Shall I not, then, be stifled in the vault,

To those whose foul mouth no healthsome air breathes in?

. . . .

Is it not like that I . . . with loathsome smells

. . . shall be distraught?"

(I am quoting from memory.)

In "Twelfth Night" the Duke says of music

"That strain again; it had a dying fall;

Oh, it came o'er my ear like the sweet south

That breathes upon a bank of violets

Stealing and giving odor."

In these most poetic lines we have hearing and smell linked together esthetically. The rich notes of the violin are associated in my mind with the emission of fragrance from dew-bathed southern roses in early June. I suppose the first poet called the scent of a flower its breath; but perhaps he did not realize as Bacon did that a breath is a sound. In his essay, "Of gardens," he says, "The breath of flowers is far sweeter in the air . . . where it comes and goes like the warbling of music . . . than in the hand."

In "Cymbeline" Iachimo describes the sleeping Imogen, and declares:

" 'Tis her breathing
Perfumes the chamber thus."

In the summer-time, when all the windows in my eerie study are wide open, the scents from the flowers and trees in the garden beat upon me in little, delicately panting waves, and somehow this sensation is associated in my mind with the song of birds and the open sky.

I do not know of any passage in literature which so exquisitely interweaves all the senses as Shakespeare's sonnet XCIX. I will quote it because it illustrates how I interpret the sensations which come to others through the eye and the ear with smell.

"The forward violet thus did I chide,
'Sweet thief, whence didst thou steal thy sweet smells,
If not from my love's breath? The purple pride
Which on my soft cheek for complexion dwells,
In my love's veins thou hast too grossly dyed.
The lily I condemned for thy hand,
And buds of marjoram had stolen thy hair;
The roses fearfully on thorns did stand,
One blushing shame, another white despair,
A third, nor red nor white, had stolen of both,
And to his robbery had annex'd thy breath;
But for this theft, in pride of all his growth,
A vengeful canker eat him up to death.
More flowers I noted, yet I none could see,
But sweet or color it had stolen from thee.'"

You see why I stress the importance of the sense of smell. I associate it with poignant memories, deep emotions and the glories of poetry.

I recall a description I once read in French—unfortunately, I cannot remember the author's name—of a man who stood on the seashore with the wind blowing in his face, full of heart-stirring odors. He threw up his arms ecstatically, taking in great "mouthfuls of air," as the French idiom so vividly expresses it, while his heart overflowed with tender memories. The scents from land and ocean brought back to him the loved hearth of his boyhood where he had gazed into the fire, seeing magical pictures, the kisses of his mother, the fine, virile personality of his father, the orchard where he had played, and the summer nights when he wandered under the stars with great thoughts in his brain. Throughout the passage it is the sensation of smell, not sight or hearing, which awakens the deepest emotions.

I wonder how many people are aware of the complex odors in a house that has been lived in a long time. They give me a comfortable sense of hospitality.

They suggest cheery winter fires and peace and sweet family intimacies. There are lingering scents of perfume and garments in closets and drawers, and appetizing odors of cookery, which some people find extremely unpleasant, but which seem to me kindly.

Balzac attached much meaning to the smells that came to him while he worked in his attic. He was sensitive to the odor of brown gravy and the exhalations from the city streets. He read much of charm, and of ugliness, too, into the smell of garments and the cosmetics people used.

Pierre Loti noticed the odor of the crisp winter air in his mother's cloak when she came into the room where he lay ill, and bent over him, rosy-cheeked and drenched in sunshine.

I was much interested in an article by Stuart Mackenzie in "The American Magazine" entitled, "Smells Are Surer Than Sounds and Sights". He notes among other things that plants emit many odors beside the perfume of their blossoms. Sometimes the scents are in the wood itself, as in cedar and sandalwood, sometimes in the bark, as in cinnamon and cassia, or in the leaves, as in pines, bay, mint, thyme and lemon verbena. Others are in the fruits—orange, lemon and nutmeg. He has observed smells also in the seeds—almond and caraway, and I would add magnolia-seeds, and sometimes certain secretions are fragrant, like turpentine, and even roots have a strong odor, like the orris root. All this knowledge is a part of my equipment for getting joy out of life.

Mr. Mackenzie also says that he felt keenly his inferiority in the olfactory sense when he lived among some Western Indians. They could detect a distant camp-fire when he could not possibly perceive it. This makes me feel my kinship to the Indians; for I, also, can smell at a great distance.

Some day, when I have leisure, I will write you more on this fascinating subject. The Bible is crammed full of odor references. The patriarchal services had in them much of incense and sweet oil. If the elders who stand around the Throne of God hold in one hand golden harps, they hold in the other "Golden vials full of odours which are the prayers of the saints".

Sincerely and interestedly yours,

HELEN KELLER.

When tested objectively, Miss Keller's olfactory sense shows nothing above the normal average. Six aromatic substances were used in these tests, including alcohol, oil of wintergreen, peppermint, formaldehyde, eucalyptus and asafetida, with the results record in Table 1.

TABLE 1—ESTIMATION OF OLFACTORY SENSE.*

	Did Not Recognize	Recognized
Alcohol	1 to 32	1 to 16
Wintergreen	1 to 256	1 to 128
Formaldehyde	1 to 32	1 to 16
Peppermint	1 to 2048	1 to 1024
Eucalyptus	1 to 128	1 to 64
Asafetida	1 to 4096	1 to 2048

*Miss Keller's responses to olfactory tests correspond closely to the normal average.

In consequence of these tests, it may be said that the fundamental pathway for the sense of smell in Miss Keller does not have a demonstrable advantage in its peripheral organization.

The Sense of Taste: Gustatory sense, a specialized portion of the seventh and ninth cranial nerves, also did not show any advantage in its fundamental organization.

The Sense of Sight: Concerning vision, it may be said that Miss Keller is totally blind and has been in that condition since her nineteenth month. She can perceive neither light nor objects. Both retinas are absent. She therefore is deprived of the primary conduction paths for visual sense.

The Sense of Hearing: With reference to the auditory sense, Miss Keller is completely deaf, having neither bone nor air conduction in either ear. Concerning her bone conduction, some question might arise as she is conscious of vibratory impressions. This, however, is in all probability not due to her auditory sense, but rather to an extraordinary development of her vibratory sensibility.

The Sense of Touch: The analysis of Miss Keller's capacities in the sense of touch has been most carefully studied, and many measurements have been made by repeated testing. In these examinations, much care was exercised to prevent that fatigue which so commonly makes its appearance after the subject has been under observation for some time. When there was any doubt as to the figures obtained by these sensory measurements, they were repeated on another day. In fact, all of the estimations have been checked by frequent retesting. Sometimes the retest was made by the original observer, but just as often by a collaborator. Ultimately, an average figure was obtained from these several controls of each test.

Light Touch: The test for light touch was made by means of graded bristles corresponding with the von Frey instruments of this kind.

As far as possible, the methods of cutaneous sensory testing employed by previous observers have been applied to Miss Keller. This refers not only to the type of instrument used but to the rules regulating the tests. In examining the state of cutaneous sensibility dependent on light touch, or what might be called "point touch", as the stimulus is limited to single points on the skin, a group of four bristles was employed. These bristles were numbered 1, 2, 3, 4, respectively. No. 1 had a tensile resistance of 0.4 gm.; No. 2, a tensile resistance of 0.3 gm.; No. 3, of 0.03 gm., and No. 4, of 0.01 gm.

Each bristle was applied to each point tested 10 times successively, and the number of correct answers was noted for each bristle. In these tests, Miss Keller showed that she corresponded to the normal average in an exact and striking manner. The summary of these comparative tests is given in Table 2.

TABLE 2—ESTIMATION OF LIGHT POINT TOUCH.*

Right Side of Face†					Left Side of Face			
Helen Keller...	0.4/10	0.3/10	0.03/10	0.01/5	0.4/10	0.3/10	0.03/10	0.01/5
Average	0.4/10	0.3/10	0.03/10	0.01/5	0.4/10	0.3/10	0.03/10	0.01/5
Right Forearm‡—Ventral					Left Forearm—Ventral			
Helen Keller...	0.4/10	0.3/10	0.03/10	0.01/5	0.4/10	0.3/10	0.03/10	0.01/5
Average	0.4/10	0.3/10	0.03/10	0.01/5	0.4/10	0.3/10	0.03/10	0.01/5
Right Finger Tips—Palmar					Left Finger Tips—Palmar			
Helen Keller...	0.4/10	0.3/10	0.03/2	0.01/0	0.4/10	0.3/10	0.03/4	0.01/0
Average	0.4/10	0.3/10	0.03/6	0.01/2	0.4/10	0.3/10	0.03/6	0.01/0
Right Fingers—Dorsal					Left Fingers—Dorsal			
Helen Keller...	0.4/10	0.3/10	0.03/10	0.01/4	0.4/10	0.3/10	0.03/10	0.01/5
Average	0.4/10	0.3/10	0.03/10	0.01/5	0.4/10	0.3/10	0.03/10	0.01/5

*Bristles in fractions of gram of tensile resistance. The denominator indicates correct responses in 10 tests. The numerator indicates the bristle employed.

†"Side of face" includes four areas: forehead, supra-orbital region, cheek and chin.

‡"Forearm" includes two areas: (a) elbow and (b) middle of forearm.

Two-Point Recognition: The recognition of two points placed simultaneously on the skin is probably not merely confined to the operation of cutaneous receptors, but undoubtedly is influenced by the deeper receiving organs essential to the recognition of pressure. Two-point recognition, moreover, belongs unquestionably to a type of sensory organization requiring a higher level of cortical activity than that necessary for light touch. Indeed, it is a question in my mind whether two-point differentiation on the skin should not be considered as a higher sensory synthesis, particularly since it shows considerable variation in persons subjected to different degrees of training. This view may suffice to explain the discrepancies in observation made on different subjects. The instrument used for these tests was a pair of exactly calibrated calipers, the sharp points of which were slightly ground down to avoid producing pinpoint stimulation. Similar calipers with pointed ends were also employed as a control, but the figures obtained from them have not been tabulated since it appeared that the pressure elements of sensation entered too much into such tests. Dr. Byron Stookey's two-point esthesiometer was also employed in checking the observations made by other instruments. For practical purposes, it is the most convenient instrument for studies in two-point recognition.

In comparing Miss Keller's two-point tests with those of the normal person as averaged from 10 normal subjects tested, there appeared to be no essential difference. Miss Keller's two-point recognition was the same as the normal average. This fact seems to be particularly interesting, since Dr. G. Stanley Hall, in consequence of similar tests of Laura Bridgman, found that she possessed a two-point

recognition two or three times greater than that of the average person. My own experience with Miss Keller leads to some question as to the validity of Dr. Hall's conclusion, for in comparing figures which I have obtained with Helen Keller, I find that they correspond with remarkable closeness to those recorded for Laura Bridgman. As has been stated, Miss Keller herself is quite similar to the average normal adult; in fact, one blind girl whom I tested had a much greater acuity in two-point recognition than Miss Keller. Dr. Hall noted that Miss Bridgman could detect a distance of 0.5 m.m. on the tip of her tongue; Miss Keller could do this also, and indeed it is possible for many normal adults.

In the tests of two-point recognition Miss Keller was able to detect the eye of a needle by applying the latter to the tip of her tongue and, having done so, she finally succeeded in introducing a thread into the eye after a period of concentration and—as she expresses it—patience. This same concentration and patience are, I believe, the secret of much of Miss Keller's sensory superiority.

As bearing on the differences between Laura Bridgman and Helen Keller in two-point recognition, there is a fact which seems to support the postulate already made, namely, that this form of sensation belongs to the higher orders of sensory syntheses, and is largely conditioned by training. For many years Miss Bridgman employed most of her spare time in doing needlework for pin money. She made such beautiful embroidery and developed great facility with her needle. This continued use of so fine an instrument as the needle would have served to train her two-point recognition to an extraordinary degree. It might be presumed that reading Braille would similarly train two-point recognition, but the Braille points are relatively coarse and the intervals between them are not small, so that such an exercise would not necessarily develop a high degree of sensory synthesis in two-point recognition, although Miss Keller is an untiring reader. She uses the typewriter a great deal, but she has not cultivated her needlework to the extent that Laura Bridgman did. It is on the grounds of this special training to which Miss Bridgman subjected herself that I attribute the difference in her two-point recognition which Dr. Hall claims was two or three times better than the normal average, and it is to the lack of such intensive training that I would attribute Miss Keller's less highly developed two-point recognition. I should feel that a two-point recognition two or three times greater than the normal, as Miss Bridgman's was said to be, is perhaps only approximate and may give a somewhat exaggerated idea of her actual capacities in this form of sensory perception.

It is my conclusion that Helen Keller does not show any advantage in two point recognition over the normal average, and such advantage as Laura Bridgman is said to have manifested should be ascribed to special training in the associations of this complex sensory synthesis.

A comparative summary of Miss Keller's two-point touch recognition is given in Table 3.

TABLE 3—ESTIMATION OF TWO-POINT TOUCH RECOGNITION.*

	Right			Left		
	Forehead	Cheek	Chin	Forehead	Cheek	Chin
Helen Keller.....	1.25	1.25	1.0	1.25	1.25	1.0
Average	1.50	1.50	1.0	1.50	1.50	1.0
	Arm	Forearm	Palm	Arm	Forearm	Palm
Helen Keller.....	7.50	5.00	3.0	7.50	5.00	3.0
Average	8.00	5.00	3.0	8.00	5.00	3.0
	Thumb	Finger	Thigh	Thumb	Finger	Thigh
Helen Keller.....	1.00	1.00	25.0	1.00	1.25	25.0
Average	1.25	1.25	25.0	1.25	1.25	25.0
	Calf	Foot	Toes	Calf	Foot	Toes
Helen Keller.....	20.00	5.00	1.5	20.00	5.00	1.5
Average	22.00	5.00	1.5	22.00	5.00	1.5

*The separation distance is expressed in millimeters.

Touch Localization: In the tests of touch localization, it was necessary to employ a somewhat specialized method in order to obtain clear responses from Miss Keller. To do so, I asked her to indicate on the surface of the skin the point where I touched her. The observer employed a fine pencil point of soft lead. Miss Keller herself also used a similar lead pencil. The point touched by the observer left a small black dot on the skin. In endeavoring to locate this point Miss Keller's pencil also left a dot on the skin. The distance between these two points was measured to show the error in exact localization. The same method was employed in testing the normal adult controls. There is always considerable error in this touch localization, varying in the normal person from 3 to 25 m.m. or more, depending on the area. Miss Keller's margin of error was no greater and no less than that of the average. In evaluating touch localization, it must be regarded as a fairly high degree of tactile discrimination. It certainly involves more than the cutaneous receptors, especially as the test was devised and applied in this study. The pressure sense entered into the sensory syntheses necessary to the sensation. Such stimuli are essential to touch localization if it becomes accurate, although light touch may be fairly well localized, as, for example, the crawling of an insect over the skin. But I have noticed in myself that localization unaided by vision has a somewhat wider margin of error than when a certain degree of pressure enters the synthesis. My conclusion, therefore, is that the most accurate touch localization

depends on subcutaneous receptors co-operating with those in the skin itself.

The summary of Miss Keller's touch localization in several parts of her body is given in Table 4.

TABLE 4—ESTIMATION OF TOUCH LOCALIZATION.

	Right			Left		
	Forehead	Face	Chin	Forehead	Face	Chin
Helen Keller.....	4.0	3.0	2.0	4.0	3.0	3.0
Average	3.5	3.0	2.5	3.5	3.0	2.5
	Shoulder	Arm	Forearm	Shoulder	Arm	Forearm
Helen Keller.....	25.0	22.0	20.0	25.0	22.0	20.0
Average	22.0	20.0	20.0	22.0	20.0	20.0
	Palm	Thumb	Fingers	Palm	Thumb	Fingers
Helen Keller.....	4.0	4.0	4.0	4.0	4.0	4.0
Average	4.0	4.0	4.0	4.0	4.0	4.0
	Knee	Calf	Foot	Knee	Calf	Foot
Helen Keller.....	25.0	25.0	15.0	25.0	25.0	15.0
Average	25.0	25.0	15.0	25.0	25.0	15.0

Testing Cutaneous Sense by Electric Currents: One of the most useful and accurate means of testing skin sensation is by means of a small examining electrode (1 c.m. in diameter) by means of which a faradic current is applied to different parts of the body. I have standardized this means of testing through many examinations, using an inductorium of 1,000 coils over the primary, and estimating the point of sensory perception in centimeters of coil distance over this primary. The results of tests of Miss Keller over different areas are in close accord with those of the normal average person. The summary of these tests is given in Table 5.

TABLE 5—ESTIMATION OF FARADIC TOUCH—INDUCTION, 1,000 COILS.*

	Right Ventral Surface			Left Ventral Surface						
	Neck	Arm	Wrist	Neck	Arm	Wrist				
Helen Keller.....	2.2	4.0	3.9	2.2	4.2	3.9				
Average	2.5	4.0	3.5	2.5	4.0	3.5				
	Right Dorsal Surface			Left Dorsal Surface						
	Neck	Arm	Wrist	Neck	Arm	Wrist				
Helen Keller.....	2.2	3.6	3.0	2.2	2.6	3.0				
Average	2.5	3.0	3.0	2.5	3.0	3.0				
	Right Finger Tips—Palmar					Left Finger Tips—Palmar				
Helen Keller.....	3.3	3.0	3.0	2.6	2.4	3.0	3.0	2.7	2.7	2.1
Average	3.0	3.0	2.5	2.5	2.5	3.0	3.0	2.5	2.5	2.5
	Right Finger Tips—Dorsum					Left Finger Tips—Dorsum				
Helen Keller.....	3.8	3.5	4.0	3.2	4.0	3.6	3.4	3.5	3.2	3.5
Average	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5

*Estimated in centimeters of coil distance.

The galvanic current was also employed in estimating the acuity of skin sensation. The records were here made in milliamperes from the cathode applied as the examining electrode. In these tests, Miss Keller corresponded closely with the normal average.

Pressure Sense: Tests were made by means of a pesometer in which the differentiation in focal pressure on the points of the skin was estimated in grams. The diameter of the surface applied to the skin in the pesometer used was 1 m.m. As a result of these tests, Miss Keller was found to correspond accurately to the normal average adult. A summary of focal pressure differentiation in grams is given in Table 6.

TABLE 6—SUMMARY OF FOCAL PRESSURE DIFFERENTIATION (IN GRAMS).

	Right			Left		
	Upper Part of Face	Lower Part of Face	Shoulder	Upper Part of Face	Lower Part of Face	Shoulder
Helen Keller.....	3.2	3.5	9.4	3.2	3.2	9.4
Average.....	3.5	3.5	9.0	3.5	3.5	9.0
	Arm	Forearm	Palm	Arm	Forearm	Palm
	Back of Arm	Back of Forearm	Back of Head	Back of Arm	Back of Forearm	Back of Head
Helen Keller.....	9.0	8.4	6.4	9.0	8.2	6.4
Average.....	9.4	8.0	6.0	9.4	8.0	6.0
Helen Keller.....	9.4	9.4	7.25	9.4	9.4	9.4
Average.....	9.4	9.4	9.4	9.0	9.4	9.4
	Fore-finger	Middle Finger	Ring Finger	Fore-finger	Middle Finger	Ring Finger
Helen Keller.....	5.2	5.2	5.2	5.2	5.2	5.2
Average.....	5.2	5.2	5.2	5.2	5.2	5.2

Surface pressure was measured as compression by means of a cuff in connection with a manometer, the pressure being recorded in millimeters of mercury. These compression tests gave the following results:

In increase in pressure of from 10 up to 40 m.m. a rise of 1 m.m. and a fall of 2 m.m. were detected on both arms, forearms and hands. A rise of 1 m.m. and a fall of 2.5 m.m. were detected on both thighs. A rise of 2 m.m. and a fall of 1 m.m. were detected in both legs at about the middle of the calf. In compression tests in which the mercury column rose from 40 to 140 m.m., the interval of differentiation was somewhat wider. On both arms, forearms and hands a rise of 5 m.m. and a fall of 10 m.m. were detected. In both thighs and legs a rise of 5 m.m. and a fall of 10 m.m. were appreciated. These tests as applied to Miss Keller gave results with which the control tests in 10 normal adults corresponded with such minor variations that the differences were negligible. In other words, the measurements of Miss Keller's pressure sense by compressions were similar to those of the normal average adult.

Temperature Sense: The temperature component of contact sense has always created great difficulties in metrical estimation. The procedure followed in evaluating this type of sensibility in Miss Keller was a series of tests by means of electric thermophores. Two ther-

mophores were used, each set at a different temperature. Each was maintained constant by means of an adjustable rheostat. The surface applicator was circular and measured 5 m.m. in diameter. One thermophore was set at 98.5° F. and the other at 100° F. The applicator was allowed to remain on the skin for four seconds; an interval of four seconds elapsed before the second application was made, during which the applicator was held in position for four seconds also. It was found that neither Miss Keller nor any of the normal adult controls was able to distinguish less than 1.5° F. in the sensitive parts of the body. The two thermophores applied in the manner indicated to the forehead, cheek and chin of both sides, to five areas on the arm and forearm, to six areas of the palmar and dorsal surfaces of the hand, to each phalanx of all of the fingers on both sides and to two areas on the chest and on the abdomen, gave prompt and accurate responses. Two areas on the thigh, the calf and the dorsum of the foot gave accurate but somewhat hesitating responses on both sides. With the thermophores set at 120° and 110° F., respectively, following the same method of testing over the same areas indicated in the previous tests, the responses obtained were all prompt and accurate except on the back of both thighs where there was considerable hesitation, but a response which eventually was accurate. In all of these tests, Miss Keller corresponded closely with the normal average adult controls (Table 7).

TABLE 7—TEMPERATURE DISCRIMINATION ESTIMATED BY THERMOPHORES.*

	Right			Left		
	Cheek	Neck	Shoulder	Cheek	Neck	Shoulder
Helen Keller.....	1.5	1.5	1.5	1.5	1.5	1.5
Average	1.5	1.7	1.5	1.5	1.7	1.5
	Arm	Forearm	Palm	Arm	Forearm	Palm
Helen Keller.....	1.5	1.5	1.5	1.5	1.5	1.5
Average	1.5	1.5	1.5	1.5	1.5	1.5
	Fingers	Chest	Abdomen	Fingers	Chest	Abdomen
Helen Keller.....	1.5	1.5	1.5	1.5	1.5	1.5
Average	1.5	1.5	1.4	1.5	1.5	1.4
	Thigh	Leg	Foot	Thigh	Leg	Foot
Helen Keller.....	1.5	1.5	1.5	1.5	1.5	1.5
Average	1.4	2.0	2.0	1.4	2.0	2.0

*The estimations made was in degrees Fahrenheit between 98.5 and 100.

Vibratory Sense: The vibratory component of sensibility was also measured. In this connection, it should be noted that this sense is by no means dependent on the bone for its ultimate conduction. Vibration is easily felt on the skin, as when applied on the web between the thumb and the index finger or other fingers. Vibration may be perceived on regions of loose skin picked up between the thumb and finger, without the intervention of the bony system. Vibration sense plays an extremely important role in the information

that it conveys to Miss Keller. She is able to distinguish much that is going on in the household through this sensory avenue. When she is in her study writing, meal time is announced to her by someone stamping on the floor in the dining room. She is able to recognize this stimulus on the floor above. To a certain extent she can distinguish different persons by their tread on the stairs or on the floor. Seated in her own room, she is able to recognize the flight of airplanes passing in the vicinity of her home. This, of course, is an example of vibration transmitted to the body through the air from a distant source of stimulation. It illustrates some of the inconsistency in regarding vibratory sense as restricted to actual contact sensibility. Miss Keller is also able to recognize the difference between the vibrations produced by implements used in the house, such as sawing, planing or hammering; but her most remarkable development in vibratory perception is her latest achievement of "listening" to the radio by means of her hands. A special loud speaker has been constructed for her under the direction of Mr. Keith Henney. Miss Keller finds much enjoyment in the radio programs which she hears in this way. Up to the present time she has not learned to interpret spoken language on the radio, but she has a keen appreciation of music and is able to distinguish different selections which she has previously heard. She gives evidence of her musical appreciation by her change of expression. Slow and sad music causes a serious expression. Quick music and dance music cause her to manifest rhythmic actions characteristic of dancing. Another remarkable achievement in utilizing the vibratory sense is seen in her ability to interpret a spoken language by placing her hand on the face of the speaker so that the thumb rests on the larynx, the middle finger on the lips and the index finger on the ala of the nose. Thus she distinguishes the vibratory effects of articulation and can follow conversation with ease. An interesting picture showing Miss Keller thus engaged appears in one of her books, "The Story of My Life". Here she is shown conversing with Mr. Joseph Jefferson and her teacher, Mrs. Macy. They are apparently holding an animated conversation in which Helen Keller is not the least enthusiastic participant.

In testing Miss Keller's vibratory sense, two metrical procedures were employed: The first was the application of tuning forks with 128, 256, 512, 1,024 and 2,048 vibrations, respectively. The highest vibration that Miss Keller was able to perceive by this means in any part of her body was 1,024 (high C), but for most areas of her body her highest range was 512 (C₂). The second procedure employed was the Henney pallesthesiometer, which records on a scale of radio cycles. This is a new instrument, especially devised for measuring

Miss Keller's vibratory perception and for which I am indebted to Mr. Keith Henney. It is extremely delicate and gives with great accuracy the upper and lower ranges of vibratory sensation received from all parts of the body.

A third method was employed for testing surface vibration, in which vibratory sensation over large areas of the body was examined by an especially devised loud speaker mechanism attached to the pallesthesiometer. In all of these tests, Miss Keller's range of vibratory sense corresponds strikingly to that of the normal average adult.

A summary of vibratory sense as tested by tuning forks and the pallesthesiometer is given in Tables 8 and 9.

TABLE 8—ESTIMATION OF VIBRATION SENSE BY TUNING FORKS.*

	Right			Left		
	Upper Part of Face	Middle Part of Face	Lower Part of Face	Upper Part of Face	Middle Part of Face	Lower Part of Face
Helen Keller.....	1,024	1,024	1,024	1,024	1,024	1,024
Average	1,024	1,024	1,024	1,024	1,024	1,024
	Occiput	Acromion	Olecranon	Occiput	Acromion	Olecranon
	Carpus	Fingers	Spine	Carpus	Fingers	Spine
Helen Keller.....	1,024	1,024	512	1,024	1,024	512
Average	1,024	1,024	512	1,024	1,024	512
	Knee	Shin	Ankle	Knee	Shin	Ankle
Helen Keller.....	512	512	512	512	512	512
Average	512	512	512	512	512	512

*Oscillations indicate 1,024 (C³), 512 (C²).

TABLE 9—FOCAL VIBRATION SENSE MEASURED BY PALLESTHESIOMETER IN RADIO CYCLES.

	Right			Left		
	Mastoid	Neck	Shoulder	Mastoid	Neck	Shoulder
Helen Keller.....	1,100	1,100	1,100	1,100	1,100	1,100
Average	1,100	1,100	1,100	1,100	1,100	1,100
	Occiput	Scapula	Elbow	Occiput	Scapula	Elbow
	Forearm	Wrist	Palm	Forearm	Wrist	Palm
Helen Keller.....	1,600	1,100	900	1,600	1,100	900
Average	1,600	1,100	1,000	1,600	1,100	1,000
	Thumb	Fingers	Shin	Thumb	Fingers	Shin
Helen Keller.....	1,400	1,400	520	1,400	1,400	520
Average	1,400	1,400	520	1,400	1,400	520

Motion Sense: In the next observations, tests were made of postural and motion sense. The first of these was the actual measuring of motion sense, for which a new instrument was designed, called the "kinetometer". This instrument is so arranged that it is capable of measuring changes in the limbs or parts of the limbs in millimeters. It consists of a platform on which the part to be studied may be placed. The platform itself may be elevated or depressed by means of a delicately adjusted worm-screw and the distance of such

motion measured in millimeters. The movable platform is so divided that the entire limb, the hand, or each finger as well as the several joints of the finger, may be moved separately and the range of motion perception thus recorded.

The summary of motion sense measured in millimeters is given in Table 10. From these tests, it is evident that Miss Keller is, if anything, less acute in the recognition of motion than the average normal adult.

TABLE 10—ESTIMATION OF MOTION SENSE.*

Right Joint Flexion				Left Joint Flexion			
	Elbow	Wrist	Thumb	Elbow	Wrist	Thumb	
Helen Keller....	3	2	2	2	2	2	
Average.....	2+	2+	2+	2+	2+	2+	
Left Joint Extension				Right Joint Extension			
	Elbow	Wrist	Thumb	Elbow	Wrist	Thumb	
Helen Keller....	2	2	2	2	2	2	
Average.....	1+	1+	1+	1+	1+	1+	
Right Joint Flexion				Left Joint Flexion			
	Phalanx	Second Phalanx	Third Phalanx	First Phalanx	Second Phalanx	Third Phalanx	
Helen Keller....	3	3	3	3	3	3	
Average.....	2+	2+	2+	2+	2+	2+	
Right Joint Extension				Left Joint Extension			
	First Phalanx	Second Phalanx	Third Phalanx	First Phalanx	Second Phalanx	Third Phalanx	
Helen Keller....	2	2	2	2	2	2	
Average.....	1+	1+	1+	1+	1+	1+	

*This sense was measured in millimeters by the kinetometer.

Posture Sense: Posture sense was measured by means of the kinetometer, and it was found that all postures of the hand, fingers and arms were accurately appreciated by Miss Keller, although she did not show a greater capacity in this respect than the normal average.

Balance Sense: The estimation of balance sense was made by means of a rotation chair, by the Romberg position, by rotation in the standing position and by the Hitzig galvanic stimulation of the vestibule. Miss Keller showed on rotation that she did not possess a sense of direction. The rotation did not cause visceral sensation of any variety. The test of rotation for nystagmus was omitted, as certain ocular operations precluded such reactions. It is interesting in this connection to note again that Miss Keller does not have any retinas, and this, in conjunction with the fact that she is devoid of any sense of direction, may have an important bearing on certain but little understood sensory pathways connected with the eye. After repeated tests in the rotation chair, Miss Keller was able to designate with a certain degree of accuracy the direction in which she was being moved. She believed that her perception in this regard might

be explained by air currents striking her face as the chair rotated in one direction or the other. Her spatial orientation in limb movement and general co-ordination was perfect. This was determined by tests for non-equilibratory as well as equilibratory co-ordination. Miss Keller was found to possess a perfect sense of balance, in spite of the fact that there was no response from the semicircular canals of either side to cathodal or anodal stimulation of the Hitzig tests. I refrained from making the caloric tests during this series of observations, but for completeness I hope to add them in a subsequent report.

The Hurt Sense: Analysis of the hurt sense showed that to the pin point measured by the algesimeter in millimeters, to steady pressure, to sudden compression, to extremes of temperature, to vibrations below 100 oscillations, to overextension or overflexion of joints, Miss Keller's discomfort was essentially the same as that in the normal controls. The algesimeter applied to the fingers (all of the phalanges) and to the same area of both palms, to the back of the hand, to the forearm and arm, to the entire face on both sides and to the leg and foot gave the same rating for Miss Keller as for normal adults.

Overextension of the wrist and the several joints of each finger of both hands caused discomfort at the same degree of extension as in the normal. Temperature at 110° F. was uncomfortable and at 120°, disagreeable and tending to be painful. Steady thrusts at a pressure of 10 pounds on the back of either hand became disagreeable and if continued for several seconds, almost painful. Compression on both arms and forearms, as well as on both legs, at 130 m.m. of mercury became uncomfortable, and at 150 m.m. became disagreeable and painful. It is possible that if Miss Keller's hurt sense is actually less acute than in the normal person, this difference may be explained by the fact that there is a degree of stoicism in her philosophy which permits her to endure pain and distress with more fortitude than is true of most normal persons.

SENSORY SYNTHESSES.

It seems likely that the several components of contact sense are seldom employed singly. Most of one's contacts with the world depend on various combinations of these several contact components. For example, the recognition of different states of matter such as fluidity, viscosity or solidity depends on stimuli of surface touch, spreading touch, surface and spreading pressure and surface temperature as well as motion in the several parts making the contact. Not only must these elements enter into a sensory composite which gives the actual picture of the situation examined, but almost photo-

graphic memory of these conditions must be made and detained in the brain. Correlation with other types of sensation is also essential in order to permit of proper object association, recognition and naming. The texture, the size and the shape of objects with which one comes in contact through the sense of touch likewise require composite associations of the several sensory elements. One of the most important of these composites is the recognition of objects by palpation, the sensory process of which is called stereognosis. In this capacity, Miss Keller showed an extraordinary richness of association dependent on many sensory qualities derived from surface touch, surface pressure, surface vibration and surface temperature in combination with sensory elements of motion and posture. Miss Keller's stereognosis is much above that of any normal person whom I have ever tested. Not only is she able to recognize all familiar objects about her, to tell the form and size of many articles with which she has not had previous contact but she also has the ability to identify by touch the difference between a great variety of flowers and plants. This is a feat far above the capacity of most average persons even when aided by all of the senses. After testing her capacity for the recognition of form with many objects, I placed in her hand a coin, telling her that this was the one touch of nature which made all men kin. Her immediate answer was—"Pessimist". Such a response showed not merely a great rapidity in the assemblage of sensory associations related to touch but an equally quick wit and broad understanding of the world.

Miss Keller's sensory organization for the primary conduction of afferent impulses thus does not appear to be different from that of the average run of humanity. Her sensory supremacy is entirely in the realm of intellect. Here she has developed a richness of association far surpassing that of the average adult. She seems to be exceptionally capable even for the class rated as intellectual.

SENSORY DEVELOPMENT OF LAURA BRIDGMAN.

A comparison of Miss Keller's sensory equipment with that of Miss Laura Bridgman is important since all of the conclusions drawn from Miss Keller gain substantiation from this comparative study. During her life, Laura Bridgman was the subject of careful examination by Dr. G. Stanley Hall, who recorded the results of his investigations in 1879.

She was born in Hanover, N. H., in 1829, and died in 1889. Her family were farming people of sound health, good habits and average height. Both parents were rather nervous. Miss Bridgman's mother had an active mind. Laura is said to have inherited the physical peculiarities of her mother. She had convulsions during infancy and was quite delicate. When 24 months of

age, she had a severe attack of scarlet fever. Both of her eyes and her ears suppurated. She was kept in a darkened room after this sickness, and was so feeble for two years that she could not sit up unsupported. The illness left her deaf and blind and, to a great extent, deprived of smell and taste. The sight in the left eye was entirely lost. With the right eye she perceived some sensation from large and bright objects up to her eighth year, but after that time she was completely blind. When she was 5 years of age, her strength began to return, and toward the end of her eighth year she was sent to Dr. Howe, of the Perkins Institute, in order that she might be educated. As a result of her long illness, all recollections of babyhood had been effaced. Before her education was seriously undertaken, she had received some training at home. She was able to do a little sewing, knitting and other household tasks. Her parents kept her as much as possible in the sunlight, so much indeed that she often complained of a slight pricking like that of needles in the left eye. She always wore a band of green silk over her eyes. In her early years at home she became familiar with the objects about her, as to their form, weight, density and temperature. Dr. Hall believed that only most elementary impressions from the sense of sight could have helped with her mental growth. She seems to have had some conventional notions of color, in which she took great interest. It is believed that by her delicacy of touch she could distinguish green and white squares; yet on actual testing, she had no real idea of color. Dr. Hall believed that she was less blind-minded than many of the congenitally blind.

When she was 10 years of age, she wrote her name legibly for the first time. She then visited her home, recognized her father at once by touch, tasted and recognized her mother's cooking, and taught her mother the finger alphabet. She had an astonishing accuracy in measuring time, as it seemed, by intuition. She did not possess a watch until much later. Her sense of touch at this age was acute, even for the blind. It was difficult to pass her in the hall without being recognized. Her judgment of distance was extremely accurate, and she continually practiced in feeling the objects about her. When she was 12 she developed the ability of knowing when anyone touched the piano in the same room. She said the sound came through the floor to her foot and up to her head. Many of those about her thought that she was possessed of the sixth sense. It was never necessary for her to feel or grope her way about. In all her goings and comings she went straight like a bee, seeming to possess a remarkable sense of direction. She was so sensitive to vibrations that when the bell of the Perkins Institute was out of order she, who had never heard it, missed its vibrations more than anyone else.

During most of her adult life she was able to sew by hand and on the machine, and did much work of this kind. Her education, undertaken by Dr. Howe, led him to surround her with many restrictions, the psychologic justification of which may be questioned in the present day. He never permitted her to be fondled or caressed. He would not allow her to associate with boys or men and even in his own contacts with her he was most circumspect, avoiding anything but the most limited expressions of approval or disapproval. The theory which dictated this course of Dr. Howe's had its origin in the belief that all stimuli which might engender or arouse sexual feeling should be rigorously excluded. The result of these restrictions was a life very much shut in, one characterized by not a little prudishness and eccentricity. In this respect Laura's training differed greatly from that employed by Mrs. Macy with Helen Keller. Miss Keller's quick and happy responses, her brightness and charm in all social

relations bespeak the development of a delightful inner life, a spirit untouched and unspoiled by coarse associations but abounding in sympathy, understanding and love.

From a psychologic point of view, these two remarkable women afford illustrations with striking contrasts as to the manner in which the human mind may be conditioned by the training. Mrs. Macy believes that Laura Bridgman possessed a remarkably brilliant mind with critical faculties perhaps even superior to those of Helen Keller. But, however brilliant this mind may have been, it had little of the richness of Miss Keller's. Laura's education came to an end when she was 20, due to the fact that her teacher, Dr. Howe, married at this time. The steps in her education as conducted at the Perkins Institute were formulated from those used in the case of Julia Brace. She was first taught the name of common articles by pasting the names in raised letters on these articles. The second step was the association of the word with the article; then she formed her words from separate letters, and finally learned the alphabet.

In all of her training it was necessary to hold her back, because she was most diligent and intent on her study. Through her entire life she made use of but 50 or 60 special vocal sounds. All of these were monosyllabic and seemed to have been spoken as if by accident. Nevertheless, it is believed that she might have been taught to vocalize. She was thought to be eccentric but not defective. She seemed to lack certain data of thought, but not in any marked way, while her power to use what data she had was exceptional. Concerning the condition of her mind, Dr. Hall, who studied her carefully, found no reason to believe that she remembered anything previous to her childhood illness.

Although it is impossible to express in measurable terms the result of Laura Bridgman's sensory tests as, for example, in the case of Helen Keller, the several sensory components were carefully studied by Dr. Hall, and his summaries in this regard furnish a basis for this comparison.

The Sense of Smell: The olfactory sense was always defective. It contributed little to her development. In the early years of her life it is doubtful whether she had any true olfactory perception, and she never had a habit of holding articles to her nostrils. At 49 years of age, when she was tested, she did like to smell flowers, a few of which she could distinguish. Sometimes she was able to recognize cologne. She was also able to identify ammonia, but in this case it is questionable whether the identification was due to olfactory stimulation. The responses may have been dependent on the irritating effects of the ammonia. She sometimes recognized and distinguished tobacco and onions, but only when the odor from them was quite strong. Apparently there was no difference between the olfactory perception of the two nostrils.

It is at once apparent, in comparing the olfactory sense of Helen Keller and Laura Bridgman, that a great disparity exists between them. The sense of smell was much less developed in Laura Bridgman than in Helen Keller, who has distinguished it among her senses as her "landscape" or "background".

The Sense of Sight: After her eighth year, Laura Bridgman was totally blind, and such vision in her right eye as she did retain from her second year until this time was of little service to her. The contributions to the sensorium in both cases, therefore, were on a par, and vision as such did not contribute more to Laura Bridgman than it did to Helen Keller. It should not be overlooked that in one particular the two cases present a marked and perhaps far-reaching difference in the organization of vision. Laura Bridgman retained her eyes until the end of her life. Miss Keller has for many years been entirely deprived of her retinas. In this detail alone, the structural conditions in the sensory organizations of these two women differed. It may be that the wonderful sense of direction possessed by Miss Bridgman can be attributed to the fact that she retained her retinas, although they were devoid of visual function. Miss Keller's total lack of the sense of direction may in this sense be ascribed to the fact that she does not possess retinas. LeMoine compared the surprising sense of direction in Laura with that of migrating fish, and also of the bat. He thought that there must be a sixth sense, the reactions of which take place at the surface of the body.

The Sense of Taste: The gustatory sense was much impaired. Miss Bridgman was less sensitive to bitter and acid, and most sensitive to salt and sweets.

The Sense of Hearing: The tests for hearing indicate a complete loss of audition in both ears. Laura was tested by heavy tuning forks with the stems placed between her teeth. Heavy tuning forks were used with Helmholtz resonators. Pasteboard trumpets were fitted to her ears, and electric stimulation was applied to various parts of the external ear, but to no avail. On one occasion she said she thought she heard something like singing or talking. Generally her only feeling was one of vibration or jar. Her perception and conception of vibration seemed so close to ordinary auditory consciousness that a close relationship is suggested between these two elements of sensation.

The Sense of Touch: Compared with Weber's table, experiments on Laura Bridgman seemed to indicate that her tactile sense was two or three times as great as that in an ordinary person, but in these tests she showed great variations. Dr. Hall was of the opinion that the acuteness of the sense of touch was centrally conditioned, due to her unusual energy of concentration. Spots were found indicating partial dermal anesthesia. Sometimes she claimed to be sensitive to an imperceptible particle of dust, but repeated tests seemed to indicate that this was probably imaginary. In general, she had developed tactile sensation to such an extent that she could estimate the age of

visitors by feeling the wrinkles about the eye; she could tell the frame of mind by touching the face; she could also detect the degree of intelligence by the tonicity of the muscles or movements of the hands. From a characteristically flabby hand, she almost immediately recognized idiocy. All of the last mentioned sensory abilities belong to the group of stereognostic elaboration. They indicate how closely, in parallel with Helen Keller, Laura Bridgman had developed this sensory capacity. Dr. Hall found that the two compass points showed Laura's discrimination to be two or three times better than that of the person who can see.

My interpretation of this difference between Laura Bridgman and Helen Keller has already been given, as well as my opinion as to the value of such a generalized comparison in the analysis of sensation.

Laura's facial sense was not well developed, yet her hands and face seemed to be the most sensitive parts of her body. It was supposed that she could recognize the approach of another person by the undulations of the air on her face.

The Temperature Sense: Miss Bridgman was not remarkably sensitive to temperature.

The Vibratory Sense: Miss Bridgman was extremely responsive to vibration. She often spoke of herself as hearing through her feet. In this particular she resembles Miss Keller, who "listens" to the radio with her hands and hears the sounds about the house through her feet. In this way she also distinguished step and voice. From rough preliminary experiments, it would seem as though Laura had been able to distinguish a musical interval of less than one octave by touch through her right index finger. She was conscious of vibrations in her throat when she made vocal noises. From these facts it was thought that the physiologic basis of her vibratory sense might have had some characteristics of a distinct sense. On the other hand, so far as may be judged from such tests as were applied to this element of sensation, Miss Bridgman did not seem different in any way from Miss Keller. It is, of course, unfortunate that metrical records do not exist in this respect, although there is nothing in the reports of Dr. Hall which warrants the belief that Laura Bridgman had any superiority in the organization of her primary pathways for vibratory sense.

The Motion and Position Sense: The meager records of the motion and position sense leave some doubt as to the exact fundamental organization in Miss Bridgman's postural and motion sense. Judged by her general capabilities and her skilled acts, it would seem fair to presume that these components were normally developed.

The Balance Sense: In this regard, Miss Bridgman was most sensitive. She did not have ataxia of any kind. She reacted quickly to rotation which made her dizzy and produced nausea. Her semicircular canals and their nerves were said to be in good condition. She was extremely sensitive to disturbance in equilibrium, and labyrinthine impressions appeared to be normally acute.

Sensitiveness to heat, to pressure and to electric stimulation were all below the average. As to her visceral sensation, according to Dr. Hall, she never developed heart or liver consciousness.

COMPARISON OF HELEN KELLER AND LAURA BRIDGMAN.

If the lives of these two remarkable women could be considered in parallel columns, certain contrasts would be evident at a glance. There would be no doubt that Miss Keller has led a fuller life, one characterized by a greater variety of interests, more extensive contacts, greater depth of mental content and more impressive influence on her time. Laura Bridgman's limitations were largely those of circumstance. While she was not the first person of her kind to be subjected to training for the deaf and blind, much of her instruction depended on improvised innovations, and the experiments in her education were often too narrowly conceived. That she had a splendid mind seems clear. Her more or less secluded existence and limited mode of expression made it impossible for her to impress herself on a large circle of friends and acquaintances. She is known for the example she set rather than for the immediate influence which she had on her day. Quite the reverse is true of Miss Keller. She has lived a more normal life in constant intimate contact with her environment, exerting her influence on all those around her and radiating a cheery and wholesome spirit throughout the household of which she is the beloved center. She has made many friendships with important and interesting persons of her day. None of these is more touching in its remarkable understandings than that with Mark Twain. Mr. Clemens' regard for Helen Keller is expressed in many letters and in some of his writings. He appreciated her intellect, her lovable disposition, her rare social gifts. He was impressed above all by her marvelous achievements, especially that information and insight concerning the world around her by which she has learned to express herself so forcibly in spite of almost insuperable handicaps. Joseph Jefferson was another who delighted in a charming friendship with Miss Keller. In their numerous visits together, the great comedian would often play for her certain scenes of his famous comedies. She followed his acting merely by touching him, and appreciated his whimsical humor in a way that was perhaps denied to many of his more formal audiences.

Dr. Alexander Graham Bell also enjoyed the privileges of Miss Keller's intimate friendship. She numbers among her friends many authors, distinguished publishers, men of science and artists, with whom she carries on an interesting correspondence. But it is not through her capacity for friendship alone that she spreads her influence. She has done much thinking, and from her great fund of reading is able to draw most interesting and telling comparisons between the present times and the past. She has strong opinions which her special gifts and education enable her to express most effectually. Her views concerning policies and events, personalities and political topics are always interesting. It is not necessary to dwell here on her literary style or on her mastery of literature. An example of this has already been given in her letter to me concerning the significance of olfactory sense. She has decided religious convictions and a philosophy of life which have grown out of her long meditations.

One feature concerning this philosophy is the almost complete displacement of physical fear, particularly the fear of death. Miss Keller is quite stoical in these respects. I have been surprised to see the equanimity with which she bore the suffering incident to a fall in which she seriously injured her knee. I have also noted previously the fact that painful stimuli seemed to cause her less distress than is true of the normal average adult. Perhaps Miss Keller is different from other persons in her lack of fear concerning disease and death, because she firmly believes that with the passing of this life she will enter another in which all of those senses whose privileges she has here been denied will be restored to her in full, and she will then be able to hear, and to see, and to extol the glories of a new world thus revealed to her.

The differences between Miss Keller and Miss Bridgman seem to be in direct proportion to the methods of training, and to their teaching. The principles of education underlying the training of these two women were decisively different. Dr. Howe surrounded Laura Bridgman with restricted regulations and Puritanic limitations. These resulted in her exclusion from many contacts with life which would have liberalized her attitude and amplified her reactions. Her religious beliefs consisted largely of the rigorous tenets derived from early pioneer days. Her understanding of life was conditioned by a thoroughgoing Puritanism. Her teacher, Dr. Howe, was responsible for all of this, and doubtless himself believed that all of his pedagogic methods had a righteous as well as a wise foundation.

The fact that Laura's life was less full than Helens' must in large measure be attributed to the fact that her education ceased when she was 20 years of age, and that her discipline depended on fixed times

and set exercises. The method of Mrs. Macy in developing Helen Keller was totally different. From the very beginning of her instruction this ingenious teacher has arranged every experience so that it might have real pedagogic value, whether in play, in work or in rest, as well as in all other social activities. Helen Keller has been taught to capitalize every opportunity for learning from each impression entering her sensorium. This began when she was 7 years old and continues to the present day. The mind which started to unfold in childhood under the wise guidance of an exceptional teacher has continued its progressive expansion with each succeeding year. There are those who believe that Mrs. Macy operates in some occult way on Helen Keller's mind and that many of her achievements are due to some mysterious influence or suggestion exercised by the teacher over the pupil. This, in the main, is pure fiction. The relation which exists between them is that of mother and daughter. But the daughter has decided notions of her own, which even filial devotion frequently will not restrain. Their religious outlook, for example, is totally different. Where they are at one, however, is their mutual belief and implicit confidence in the methods of training and education which have made Helen Keller's mind what it is.

In the ultimate adjustments to life of Laura Bridgman and of Helen Keller, there are also certain striking differences, differences, however, which seem to be directly attributable to education opportunity. In this respect there can be no doubt that Helen Keller has been most highly — indeed, exceptionally — favored. Both women manifested a definite degree of dependence. They needed the assistance of others to make amends for the lack of sight and hearing. For example, they could not go about freely and safely in the midst of the congested conditions of ordinary life. Many of their contacts required an intermediary for their proper interpretation, and yet within certain limits their adjustments to life were so made that they were not unduly dependent. Their compensatory reactions in many respects counterbalanced their dependence.

In their independent achievements Helen Keller deserves, as might be expected, a much higher rating than Laura Bridgman. Not only are her social qualifications of a much higher order, but she has achieved distinction as an authoress, as a lecturer and as a thinker.

Laura Bridgman's accomplishments were of a far simpler order. They were outstanding in her day as representing the first notable instance of this kind. Helen Keller has developed a mode of speech and vocal expression which Laura Bridgman never acquired. Miss Keller is capable of conversing, and her conversation, although lacking in inflection, is thoroughly intelligible. At the most, Laura Bridg-

man was capable of 50 or 60 vocal sounds, few of which were recognizable words in any language although they all had definite connotation understood by her intimates.

Miss Keller is able to carry on conversation by listening to the speech of another. In doing so, she applies her fingers to the larynx, lips and nose. Laura Bridgman never possessed this accomplishment. Both of them, however, developed a high degree of manual dexterity; both were able to read with the fingers; both were able to write, and both were able to sew. In the latter respect Miss Bridgman excelled Miss Keller, who, however, has learned to use the typewriter with proficiency. If there is any difference in manual dexterity between them, it slightly favors Helen Keller.

THE DEVELOPMENT AND UTILIZATION OF THE SENSES.

Only a brief comparative summary of the degree to which the several senses were developed and utilized is necessary to indicate the striking similarity between these two women.

In the sense of smell, Helen Keller had a supreme advantage. Laura Bridgman was almost wholly defective in this regard. The post-mortem examination of her nasal cavity showed that she had suffered from a severe inflammation of the nasopharynx, after which she was totally devoid of the sense of smell for eight years. The nasal mucosa was generally diseased. She had a severe nasal catarrh which lasted all her life. The ethmoid bone and the mucous membrane covering it were seriously diseased in consequence of the inflammation. This was most particularly so on the left side. After her fifteenth year, she had slight olfactory perception.

Both of the women were blind. Helen Keller possesses no retinas and probably has no visual images. The latter fact together with her pronounced lack of sense of direction are to be made the subject of further studies. Laura Bridgman was totally blind most of her life. She had some degree of visual imagery and up to her eighth year had a feeble light perception in one eye. She possessed a most remarkable sense of direction. In this connection, it should be noted that in Laura Bridgman neither eye was removed and she retained both retinas, which, however, were insensitve to visual impressions throughout most of her life. Both upper eyelids were sunken. There was a distinct lack in the amount of orbital fatty tissue. Both eyeballs were small and indicated the presence of a prolonged severe inflammation. The right eye, about one-half the normal size, was wholly enclosed by the sclerotic coat except for a small central area 2 m.m. in diameter, in which the cornea was represented by less opaque tissue. The left eyeball was larger than the right. The cornea was altered and opaque and consisted of a small area, 4 m.m. in

the horizontal and 2 m.m. in the vertical. The eyelids were always closed. In a test of the sensitiveness of the eyes, light directed from a heliostat did not produce light perception but caused pain when concentrated. No effect was produced by gentle pressure or electric stimulation of the eyeballs.

The sense of taste in Miss Keller is little impaired, while that in Miss Bridgman was generally defective.

The sense of hearing was totally absent as such, both in Miss Keller and in Miss Bridgman. The pathologic report of Miss Bridgman's ears shows that the tympanic membrane was almost entirely destroyed and that the malleus and incus had entirely disappeared.

Laura seems to have had a certain superiority, particularly in two-point touch, although I have questioned this advantage over Helen Keller in the technical discussion of it earlier in the paper.

In temperature sense, pressure sense and electricity sense, Laura Bridgman was said to be below the average, while in these respects Helen Keller corresponded quite accurately with the normal.

In the vibratory sense both developed acute sensory powers, but there is certainly nothing to indicate any special development of the receptive ability in either of them. Such was certainly not the case in Helen Keller, who corresponded closely to the normal. It was probably not true of Laura Bridgman.

The postural and motion sense in Helen Keller was about equivalent to that of the average normal adult, and judging from the history of Laura Bridgman, the same was probably also the case with her.

The balance sense appears to have been well preserved and corresponds closely with the normal in both.

In comparison with normal adults, Helen Keller and Laura Bridgman both illustrate the same points, namely, that the peripheral receptors of the general sensory apparatus do not exhibit any compensatory development in those deprived in infancy of the special senses of sight and hearing. The fundamental organization of those senses which remained intact in Laura Bridgman and Helen Keller has no advantages over that of the normal adult. The primary sensory mechanisms were no more efficient than in the average, yet if ratings of comparative intelligence were made of Laura Bridgman and Helen Keller with the average run of mankind, it is unquestionably true that these two women would stand much higher in the scale than this average. If such an average were taken of any general community of civilized society including all walks of life, both educated and uneducated (but not defectives), there can be little doubt that both of these women would stand high in the figures of

this average. If they were compared to those who have benefited by education, through high school grades, Laura Bridgman might in certain respects show intellectual inferiorities, but her advantages in other regards would probably offset this.

Helen Keller would stand, of course, far above such a rating. In fact, if she were compared with those who have enjoyed a full college education, there is no question that her rating would far surpass the average of those trained in this way. Indeed, it is my opinion that there are few intellectual men and women living today who could develop a higher intelligence quotient than Helen Keller, with properly adjusted tests. There are many features in her intellectual development which might justify her inclusion in the class of genius.

The comparative efficiency of these two women clearly indicates that they stand well above the rank and file of the human race. This fact is important since Laura Bridgman and Helen Keller are largely dependent on a single sensory area of the brain for their intellectual rating. This area is the parietal lobe which administers the functions of general body sense as typified by the sense of touch. All other sensory areas in the brain, except those for the sense of smell and taste as specified, are inactive. It thus seems justified to infer that the parietal area for general body sensation must have reached a high degree of development in these two special cases. Laura Bridgman and Helen Keller, with a small portion of their brains in active commission, have made an intellectual and social adjustment to life which, at the very least, is equal to the average. This must mean that the average brain with all of its parts working develops only a small fraction of its potential power. Such a conclusion is important in the light of the known amplifications of association which take place in the frontal lobe when all of the senses are contributing their complements of sensory synthesis to the mental life of the person. My figures as applied to the case of Laura Bridgman would seem to show that only about 25 per cent of the brain's actual power is developed by the average of the race. This fraction is in the broadest sense a working estimate only. Whatever the exact fraction is, this much may be said: If for the present it is a matter of reproach, it may for the future be a sign of promise.

Sir Arthur Keith believes that mankind has as yet developed scarcely more than one-half of its possible brain power. Critical observation and study of the race as a whole must justify the general correctness of this low estimate. The facts here presented seem to indicate that man already has the mechanisms for a more adequate adjustment to life. He does not need any additions to his present

equipment except the determination to develop its capacity by his own unaided efforts. The social and intellectual distinctions existing among men depend not on differences in the fundamental pathways of the senses, but on the ability which the brain acquires to elaborate the impressions received by these pathways. It is the associational expansions within the brain which account for the degree of its power. In explanation of Miss Keller, Miss Bridgman and others with similar cases, it may be urged that their achievements are the result of compensation, and that unless an imperative demand for such compensation exists, no such expansion ever occurs. Many organic structures are endowed with compensatory capacities which develop under the stress of need. That need may be a sudden emergency, a sudden privation, or it may be a slow and persistent demand calling on the latent powers of a structure which would otherwise remain below its highest efficiency. This is true of the muscular system in athletes. It is also true of the excretory system in certain kinds of poisoning, or of the cardiovascular system and the respiratory system in many diseases. It is equally true of the brain as attested by facts pertaining to specialization and intellectual training.

To maintain that expansion in the powers of this organ apparent in the special cases here discussed is compensatory affirms that the brain is capable of further development. It is not necessary to rely solely on theory to uphold this postulate. The brain of Laura Bridgman is available for tests of its validity. This brain was carefully studied by Dr. Henry H. Donaldson and supplies many important facts bearing on the problem in question. Laura Bridgman's brain was removed eight hours after death. Its volume was calculated by Dr. Donaldson as 1,178 c.c. and its weight, 1,204 gm. All the cranial nerves were identified except the spinal accessory nerve. The brain stem, including the medulla, pons and cerebellum, was normal. The superior and inferior colliculi were flattened and small, as was also the pulvinar. All were much smaller than in the normal brain. These structures illustrate clearly the organic response to functional demand. Being blind and deaf, Miss Bridgman made no demand on the primary receiving centers of the functions of sight and hearing. In consequence, they showed little of their normal and proper development. The cerebral hemispheres also revealed developmental failures of the same general character. The defects here were conspicuous in those areas of the brain on which little functional demand was made. Thus, the occipital lobes were small and flattened, apparently in direct proportion to their lack of function in visual capacity. The temporal lobes were also small, and all of the fissures in them were wide, indicating a low degree of convolitional development. This

smallness and imperfect growth are significant in connection with the fact that Miss Bridgman was deaf. The insula (island of Reil) was much more exposed than in the normal brain, being more exposed on the left than on the right side. Its exposed area on the left was 128 sq. m.m., and on the right, 40 sq. m.m., a proportion of 3:1. In the normal brain the island of Reil is entirely concealed. Broca's area shows some defect which is significant, since Laura Bridgman was right-handed. The cuneus of the occipital lobe was small on both sides, but the left was smaller than the right. This deficiency has a peculiar significance in view of the fact that Laura Bridgman had light perception in the left eye until she was 8 years old. The parietal lobe was well developed, in response to touch sensation, particularly for the hand and face.

Measurements of the surface of the frontal lobe show that in this region Laura Bridgman was somewhat below the average. Table 11, a comparison made between Miss Bridgman, an insane woman and a normal adult, shows the relation of the right and the left frontal lobes to the entire surface of the brain, in percentages.

TABLE 11—COMPARISON OF FRONTAL LOBES OF LAURA BRIDGMAN, AN INSANE PERSON AND A NORMAL ADULT.

	Right, Per Cent	Left, Per Cent	Total Average, Per Cent
Laura Bridgman	36.8	39.9	38.3
Insane woman	40.0	41.0	39.5
Normal adult	38.3	40.9	39.6

The difference appears to be due to the smaller average in the depth of the sulci in the frontal lobe.

The total area of Laura Bridgman's cortical surface was as follows: right, 98,946.5 sq. m.m.; left, 101,256 sq. m.m.; total, 200,202.5 sq. m.m. This is somewhat below that of the average normal woman.

In the matter of cortical thickness, the Bridgman brain showed certain departures from the normal. The average normal thickness of the cortex varies from 2.24 to 2.91 m.m. The average of nine normal brains (all areas) was 2.92 m.m. The average of Laura Bridgman's brain (all areas) was 2.59 m.m. Not only in its thickness but also in its cell richness the cortex of the Bridgman brain showed differences as compared with the normal. In general, the large cortical cells were smaller and fewer in number than in normal brains. Laura Bridgmans' brain showed cellular defects in the visual, olfactory and taste areas. Her cortex was 89 per cent as thick as the normal.

The sensory area for general body sense was normal. The speech cortex was not particularly thin. The speech area neurons, although somewhat small, did not show remarkable departures from the nor-

mal. Perhaps the fact that the speech area (Broca's area) in Laura Bridgman was so nearly intact in a dumb person may seem surprising. Laura Bridgman made use of 50 or 60 different sounds. The only words she ever used intelligently were "doctor", "see" and "ship". But there are many indications that she followed gestures made with her hands by movements of her lips and tongue, so that the relation between the gesturing motor centers for the limbs and the gesturing motor centers for the lips, tongue and organs of speech generally is probably most intimate. This, in some sense at least, would explain why Laura Bridgman's speech area appeared to be so nearly intact.

Expansions of the brain in response to functional demand would seem to depend on some definite physical basis. It is probable that such expansions are not due in any great measure to a material increase in the cortical cells. The number of these cells is already determined in the late fetal stages. The further development of the brain depends rather on connections established between various nerve cells by means of nerve fibers. Many facts indicate that such connections are made only when called for by needed communications. One structural result of this functional call is the appearance of an insulating substance on the nerve fibers. This insulation provides a greater efficiency in the fibers as conductors of nerve impulses. The acquisition of this insulating substance is known as maturing, and the insulation itself is called myelin. This is a fatty compound of complex nature. In his study of Laura Bridgman's brain, Donaldson expressed the opinion that expansion of this organ during life is due to increased medullation, that is, increased deposit of myelin on the nerve fibers. If this is the case, and there are many reasons to believe that it is, the chief factor favoring the deposit of myelin seems to be the functional use of the several brain areas. When nerve fibers are continuously called on to convey impulses, they tend to acquire their insulating sheaths, that is, to become myelinated.

The degree of insulation in relation to the functional capacity of nerve conduction may be determined in several ways. It is possible to estimate the amount of myelin in the insulating sheaths and nerve fibers in the brain at different periods of mental development from infancy to maturity.

In the infant at birth the percentage of myelin in the brain is 35.75; at 8 days of age, 38.5; at 6 months, 43.9; at 2 years, 45; at 3 years, 48.7; at 36 years, 50.9, and at 68 years, 52.3.

These estimations show a progressive increase in the amount of myelin in the brain, which seems in direct proportion to the increase

of mental powers. In new-born cats and dogs little if any myelin is present in the optic nerve, and as the eyes remain closed for a week or 10 days, there is at that time no visual function in these lower mammals. The human fetus at seven months has hardly any myelin in the optic nerve, but an infant born prematurely at this time rapidly myelinizes this nerve. These facts indicate that myelin insulation is in direct proportion to functional demand. In this connection I will add certain observations from studies which I have made with Casamajor on the relation of myelinization to the development of behavior in animals. By this study we were able to show that special tracts in the brain myelinated as special behavioral components make their appearance, at the different stages from birth to adult life. Different animals show a different degree of myelinization according to their functional capacity at birth. In the rat, there is no myelin in the brain. The animal is born, as it were, prematurely and almost its entire care depends on the mother. It does not nurse until the eighteenth hour after birth. The dog and the cat are both capable of approaching the mother, and have certain other behavioral components immediately after birth. In their nervous system, myelinization is meager at this time. The guinea pig is born in an almost complete functional state. It sheds its milk teeth in utero, and on the second day forages for itself. Its entire brain shows almost complete myelinization at birth.

Such facts as these strongly suggest that the relation of myelinization to development of the brain is based on the functional demand for specific conduction. It is probable that the degree of myelin in the human brain varies greatly in different persons. In certain diseases and in feeble mindedness, it is distinctly low. On the other hand, the greatest brain efficiency seems to depend on the ultimate myelinization of the greatest number of association fibers within the brain.

The cases of Laura Bridgman and Helen Keller illustrate how a specific area of the brain may be expanded to make amends for deficiencies in many other areas. It is unfortunate that the myelin contained in the parietal lobe of Laura Bridgman's brain was not estimated, but this is a consideration which must be left for similar studies in the future.

It is, I believe, the concentrated and systematic application of attention which endows experience with its full richness in associational value. Such attention of course depends on continuous functional use of association fibers in the brain. Time and patience are necessary for the development of such attention. Forel has likened consciousness to a retina in which there is a floating macula of attention.

The difficulty with most of us is that this macula of attention floats too widely and too much, with the consequence that insufficient time is allowed for the needed concentration on any object or situation. As a result, there is an actual dearth of associations connected with most of the factors in our experience. Judgment and reason and all of the higher faculties suffer in consequence because the associational surplus from which they may draw their higher development is extremely meager.

The case of Helen Keller demonstrates what a brain may do under the influence of concentrated, systematic attention. It shows the expansions in understanding and in knowledge which result when the brain is properly importuned to develop them. As she maintains, the principle of Helen Keller's development has been Practice! Practice! Practice! The question naturally arises whether this principle applies to any brain, and in particular to the brain of modern man. The answer apparently should be in the affirmative. There are relatively few brains which could not be made better and more efficient by pursuing the proper methods of development. Certain difficulties have heretofore and still do arise as obstacles. They are not, however, in the brains' potential power to respond, but rather in the general lack of desire to make the necessary demands for such further development. Many observers are intensely pessimistic and doubt that the ascendant elements in the human race today will in this regard ever develop to a higher degree. Indeed, there are some reasons to believe that mentally the human race as a whole is retrograding. If one views modern man in the broad sense as all that part of the race which has existed during the historic period, it would seem in some respects that our mental capacities are inferior to those of the Greeks, probably to those of the Romans, and it may even be to those of the Egyptians. So that concerning the historic period, if any statement seems justified at all, it is that mankind has stood still intellectually. The outright pessimist will say that it has gone backward. Nor is there now apparent any reassuring prospect that the essential physiologic process (application, patience, practice) on which further development of the brain depends will have its full opportunity. The day in which we live is characterized by a predominant spirit of haste. Most of our ideals are shot through by aspirations for speed. In consequence, insufficient time is allowed for that patience, that concentration and that systematic practice which are the prerequisites of further brain development. We find ourselves in the midst of many and multiplying distractions. The rapid influx of new contrivances deceives us into believing that we are developing new ideas. With the exception of many luxuries and labor-saving devices, we lead

about the same lives as did men 300,000 years ago. Human behavior and human relations are changed but little, certainly not enough to preclude those ancient repetitious cycles of maladjustment which have led from one war to the next, from one revolution to another, which have frustrated our best civic intentions and efforts and which have left us little, if any, better off morally or intellectually than our predecessors in the early days of human history.

Yet, brain development, like all other development, follows the laws of evolution. Into this evolutionary process during the past half-century, there has come a new element. This factor has not operated heretofore, and the presence of it as a decisive influence may have far-reaching consequences. Intelligent men and women have come to recognize that there is such a thing as evolution. Being conscious of this fact they may, and undoubtedly will, direct their attention increasingly to its processes and to the nature of its underlying causes. What discoveries will be brought to light as a result of such efforts cannot be predicated. Much may properly be expected of it both to increase the understanding of our own mechanisms and to improve their capacities.

Another encouraging influence is found in the developmental history of man's brain. From my studies of the prehistoric human brain I was led to conclude that, beginning perhaps a million years ago with the ape-man (*Pithecanthropus*) and coming to modern man, the brain has shown a steady progressive development. Thus there is reason to believe that the brain of man today represents some intermediate stage in the ultimate development of this master organ of life. As a race, we appear to have developed by a fraction of its power. The greatest problem before us, therefore, is how to make a still better use of the brain. This problem may be solved only by the development of that comprehensive science which will eventually supply an adequate knowledge of all the mechanisms underlying the control of human behavior.

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DISCUSSION—AMERICAN NEUROLOGICAL ASSN.

DR. S. E. JELLIFFE, New York: Dr. Tilney said, and showed by a number of figures, that the tests of Helen Keller and the average normal, as he called it, were about the same. I seriously doubt that the quality of the tests or the nature of the tests that have thus far been devised are of any particular value. I am emboldened to make this statement more or less when I commence to consider some of the studies in eidetics made by Jaensch, of Marburg, in which the value of the synesthesiae that Dr. Tilney had already made reference to are brought out. Helen Keller showed remarkable values in associating—I do not recall the details of her associations, but the associations between smell and sight and color and form and shape and feeling, etc., are really astounding. The students of eidetic phenomena have developed just this type of testing, and it is an extremely interesting corroboration of what Dr. Tilney has pointed out, namely, the persistence or the capacity for further elaboration of the olfactory eidetic phenomena in this particular patient who has been so carefully studied. And what is true of olfactory eidetic phenomena—eidetic meaning "image"—is true, as shown amply, for other types of sensory areas. Through this particular method of investigation, elaborated by Jaensch, it seems to me we have a far greater discriminative type of testing than those which we as objective neurologists have as yet devised.

DISCUSSION—AMERICAN OTOLOGICAL SOCIETY.

PRESIDENT GOLDSTEIN: This masterful presentation by Dr. Tilney is perhaps the most far-reaching analysis concerned with neuro-otology ever presented before this organization. To me it strikes home so deeply because of my own close association and long years of study with the deaf child. I know Helen Keller. I know her fine mind, her excellent scholarship and her imaginative disposition. I taught Helen the two-step on the roof garden of the Copley-Plaza in Boston, at the time of the International Otological Congress years ago. There was a time when Helen's voice would carry a distance of only five or six feet; in a conference with Prof. White, of the Boston Conservatory of Music, suggestions were offered for improvement in resonance, volume and tone-placing and now she can be readily heard across a fair-sized auditorium.

I think, with Dr. Tilney, that Helen's outstanding developments in the face of her tremendous handicap is due largely to the quality of her mind, her intensive training and the versatile and competent guidance of her teacher, Mrs. Macy. She went through Radcliffe, with Mrs. Macy as her constant companion and mentor and passed her examination just as seriously and successfully as any normal-hearing girl.

I would like to add one thought that might be of interest. After the functional examination of biologically congenitally deaf children, we divide these into two groups: (a) Those profoundly deaf and without any evidence whatever of hearing; (b) those who have a remnant of hearing, as shown either by audiometer test, amplified human voice or other form of sound amplification.

These children are assigned to daily 10-minute stimulation by sound vibration, either of instrument or the voice. In many instances, these pupils show evidence of improvement in hearing capacity. I have convinced myself, after comparative tests taken at six-months' intervals, that this improvement in hearing capacity is not physiological in character, but is, perhaps, a mental or educational improvement in the auditory field. Even where this marked improvement in hearing is in evidence, the audiogram often shows no concurrent improvement.

DR. L. H. TAYLOR, Wilkes-Barre, Penn.: I wouldn't think of discussing this paper, but merely as an illustration of how we miss our opportunities, I will say that I saw Helen Keller when she was 6 years old. She was brought before the meeting of the American Medical Association in St. Louis in 1896. I remember we were asked to look at this little girl who was blind and deaf. Dr. Savage asked us to examine her. The ophthalmological and the otological sections at that time had not been separated. Had we known that we had before us a human being in the person of this little girl who was to develop into the most marvelous woman of the age, perhaps we would have used our brains in a little different way. The speaker said it is doubtful whether we use our brains even a small fraction of the way we could. I cite that as an illustration of how we miss our opportunities, and then think of the wonderful development in our knowledge nowadays in the training of deaf and blind children. It was a wonderful development in this case.

DR. F. L. JACK, Boston, Mass.: May I tell Dr. Tilney something about Helen Keller's sense of rhythm? Your reference to it made me think of the occasion at the meeting in Boston when I had the rare opportunity of dancing with her. I think, Mr. Chairman, you were present. Her sense of rhythm was as good as anyone's with whom I have ever danced. I thought you might be interested in this phase of it. You spoke also about her probably having an absence of the sense of direction. I started this dance the usual way—I was going to make it my dance; but I soon found it was very much easier to go her way, and we hit it off very nicely.

DR. N. H. PIERCE, Chicago, Ill.: I know that every man here appreciates very deeply the speaker's kindness in coming here and delivering this stimulating address. I had almost reached the conclusion that the human mind could not develop very much more than it has. I think he has proved the contrary and I move you, therefore, that the Society extend to him a vote of thanks by rising.

TUMORS OF THE NOSE AND THROAT RELATED TO DEVELOPMENTAL DEFECTS.*†

DR. LOUISE H. MEEKER, New York.

There is a new interest in the relation between the development of the embryo and the formation of tumors. Cohnheim¹ believed that tumors arise from tissue misplaced during the growth of the embryo or from superfluous cells which have retained their embryonic character but are not necessarily displaced. This should include the persistence of embryological structures that normally disappear. Ewing² remarks that from a survey of tumors arising from such sources it would seem that tumor genesis were chiefly a question of the mechanics of development. Not all aberrant cell groups or persistent embryonal structures give rise to tumors however, and additional factors are needed to explain the ultimate behavior of such embryonal rests.

The complicated growth of the human embryo is nowhere better exemplified than in the head. The early embryo is characterized by a system of anterior and lateral processes or arches which are separated by fissures. These curve ventrally and unite to form the walls of the cavities of the mouth, nose and throat. During the first month the human embryo presents a large mouth cavity bounded in front by a fronto-nasal process, on the side by maxillary processes and behind by mandibular processes (Fox³). The hinder arches are the hyoid and first, second and third branchial. At the end of six weeks the embryo presents mesial and lateral nasal processes separated by the olfactory grooves. The maxillary processes grow forward to meet the nasal processes. The mandibular processes fuse to form the chin. The hyoid arch lies just beneath the mandible and overlaps the branchial arches which are hidden beneath it. Later entodermal outpouchings and epidermal invaginations produce complicated series of readjustments up to the third, fourth and fifth months (Fig. 1). The Eustachian tube is formed from the first pharyngeal pouch and the external meatus from the first branchial cleft. The fate of the other arches and clefts is as follows: The maxillary and mandibular

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arches form the upper and lower jaws. The hyoid arch forms the hyoid bone and the first, second and third branchial arches take part in the formation of the tongue and side of the neck, including the thyroid cartilage. A normal adult arrangement should result, but mal-development to some degree is so common that certain types are very familiar. The types most frequently encountered are persistent branchial clefts and aberrant glands. Frazer¹ objects emphatically to the term branchiogenetic, asserting that man has only a phylo-

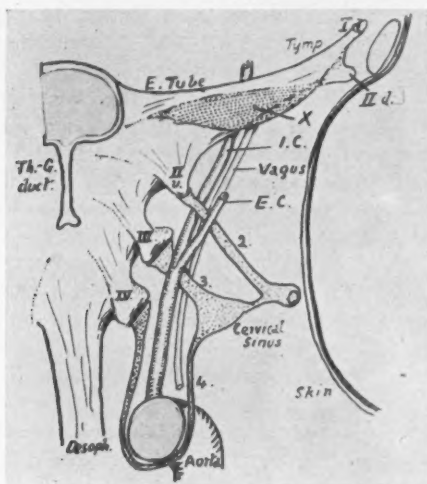


FIG. 1. (1) Lateral view of the pharynx in a 6.5 m.m. pig. M². (Fox). (2) Dorsal view of the pharynx in the same embryo. D.A. 1, dorsal apex of first pharyngeal pouch; HYP., hypophysis; Ph.P. 1-3, pharyngeal pouches; S.P., Seessel's pocket; S.T.P., sulcus tympanicus posterior; S.T.T., sulcus tubo-tympanicus; S.T.Ty., sulcus tensoris tympani; V.D. 1-3, ventral diverticula of the pharyngeal pouches; P.P. 4, posterior process of the fourth pouch x 50, reduced 1/3 (Fox). (3) Ventral view of pharynx and larger blood vessels in the same embryo. HYP., hypophysis; Ph.P. 1-4, pharyngeal pouches; V.D. 1-4, ventral diverticula; M., mouth; Tr., trachea; Ao. 2-5, aortic arches; D.Ao., dorsal aorta; Pul., pulmonary artery; T.Ao., truncus arteriosus; Tyr., thyroid; Ch.Ty., chorda tympani x 50, reduced 1/3 (Fox).

genetic memory of a branchiate stage in evolution. According to his description the pharynx of the human embryo possesses in its floor a series of visceral arches and intervening grooves which do not correspond to the gill clefts in fishes. The visceral grooves end in lateral pouches lying in contact with the epiderm. These lateral pouches have dorsal and ventral angles spreading from their lateral wall and as the embryo grows, each pharyngeal pouch presents individual variations, some angles are smoothed out and others are nar-

rowed or widened. The ventral angles carry their ectodermal contacts with them as they sink from the surface. A fold grows over them from the dorsal aspect extending from the second arch to the pericardial region and this forms a recess, the precervical sinus. This sinus should disappear at the end of the second month. Accidents in the course of an orderly development yield the so-called branchial cysts and tumors. Frazer considers "that his description is one of more practical application" (Fig. 2). It is evident that variations in location determine the type of epithelium, whether pharyngeal (entodermal—Fig. 3) or epidermoid (ectodermal). A further considera-

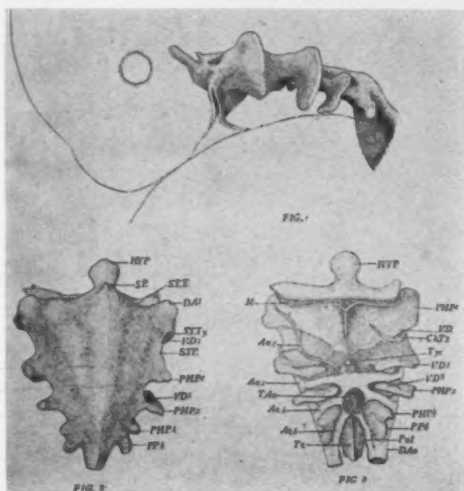


Fig. 2. Schematic figure to show the vestigial structures in the neck, with their relations to main arteries and nerves. Id. IId, Dorsal angles of 1st and 2nd lateral pouches. IIV, III, IV, "Internal pharyngeal, ducts" derived from ventral angles of 2nd, 3rd and 4th lateral pouches. 2, 3, 4, "External pharyngeal ducts" derived from 2nd, 3rd and 4th external grooves (Frazer).

tion is the possibility of metaplasia (Fig. 4) as a result of inflammation so that pharyngeal derivatives may show also an epidermoid character. Terrier and Lecene⁷ discovered what they called tonsillar tissue in a branchial cyst wall and called it "type amygdalline" (Fig. 5). Frazer said he saw thymus in a cyst wall and considered it a "memory of subepidermal thymus seen in the mud eel" (Fig. 6).

That heredity plays a part cannot be doubted. Very recently a report by Precechtel⁶ records seven members in three generations that had either congenital fistulas of the neck, diverticula of the



Fig. 3. Branchial cyst. (a) Cystic spaces lined by ciliated epithelium. (b) Pharyngeal muscle. (Removed at third operation).

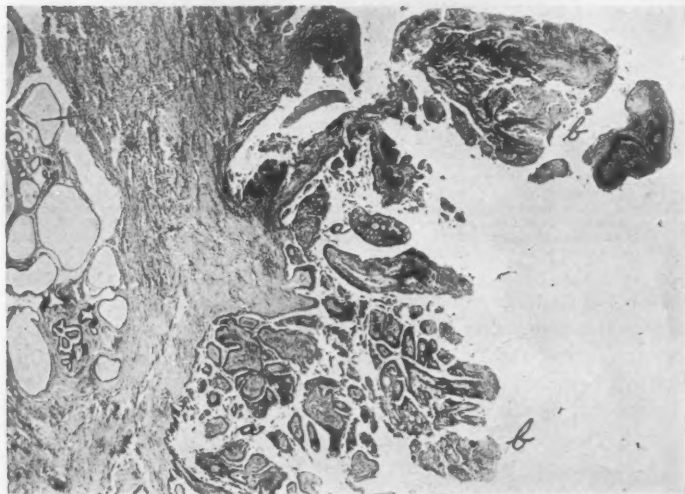


Fig. 4. Branchial cyst. Papillary lining with (a) ciliated columnar epithelium and (b) stratified squamous epithelium (metaplasia).

pharynx or branchial cysts. Bailey⁷ states that the records of necropsies at the London Hospital showed many cysts in relation to the pharynx that were lined by columnar epithelium. These cysts gave rise to no symptoms during life.

Hlavacek⁸ very recently reported two cysts of ectodermal origin that extended into polyps in the pharynx. The polyps had pedicles several centimeters long. The intralaryngeal branchial cyst reported by Watson⁹ closely resembled that in Imperatori's¹⁰ case. In both a large multilocular cyst projected from the vocal cord into the cavity of the larynx. New¹¹ had previously reported a biloculated cyst of



Fig. 5. Branchial cyst. (a) Stratified squamous epithelium with wall of lymphoid tissue. Two lymph follicles are at left centre and extreme left. "Type amygdalline."

the neck that communicated through the thyrohyoid ligament with a portion within the larynx. The cyst inside the larynx was sessile, growing from the inner surface of the aryepiglottic fold. His report includes a reference to an earlier similar case in the literature. Whether carcinoma arises from these branchiogenic cysts is a question much disputed at the present time.

Within the nose we find also examples of cysts due to abnormal development, such as the displaced ethmoid cells. Cavities due to this malformation are found in the turbinate bodies not infrequently. Nasal polyps occasionally contain large cavities lined by perfectly

developed ciliated epithelium. These cavities are considered displaced ethmoid cell derivatives (Fig. 7). The examination of the cartilage plates of 75 nasal septums has disclosed central cysts in 5 per cent, supposedly from a similar origin. The surfaces of each septum bulged symmetrically on both sides.

The thyroid gland first develops at the roots of the tongue at the foramen caecum. From this point it sinks downward as the neck elongates and develops lateral lobes lying in front of the thyroid cartilage. A strand of epithelial cells may remain in contact with the foramen caecum and form the thyroglossal duct. The thyroid gland-

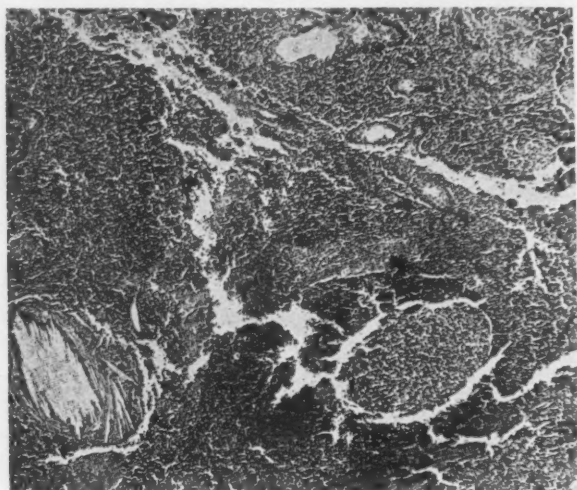


Fig. 6. Wall of branchial cyst with thymus tissue. Hassall's corpuscle filled with cholesterol crystals at the left. M-61 years (Meeker).

dules have a wide distribution in the lower animals, for example in the salmon, and may be found in man anywhere from the base of the skull to the clavicle or below, including the cavity of the larynx. These give rise to tumors in some instances (Fig. 8). Two carcinomas from aberrant thyroid glandules have been reported recently, one in the tonsil and the other at the base of the tongue (Ziemssen¹², Heise¹³).

Mixed tumors of salivary glands are not very rare. They present a mixture of cartilage, myxomatous tissue, epithelium and bone of embryonal type. Our own series includes such tumors removed from

soft palate, hard palate and nasopharynx and in one instance replacing one tonsil (Fig. 9). Recent reports duplicate this distribution, one from soft palate in man, age 57 years, size of an apple (Koch¹⁴), one from nasopharynx in a boy age 7 years, and one replacing the right tonsil and projecting into the nasopharynx.

Chondromas are tumors formed of cartilage. They may be found in the nose and throat, are usually classed under neoplasm arising from developmental displacements of tissue. Another theory attributes them to inflammation, and a combination of both is possible. Chondromas have been observed in one family in several members of three generations (Weber¹⁵). They may be found at any point in

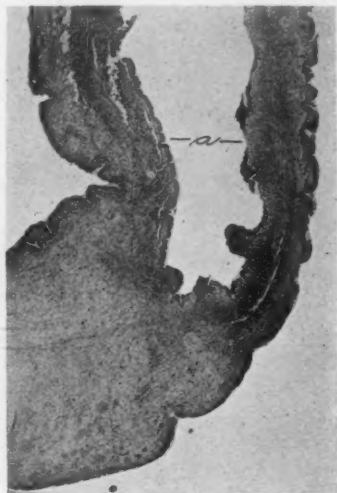


Fig. 7. Nasal polyp with cyst lined by ciliated columnar epithelium (a).

the nasopharynx and are seen in the larynx and in the neck from misplaced islands of cartilage associated with branchial cleft remnants. A recent chondroma reported by Woodburn¹⁶ occurred in a man age 75 years. A rounded swelling covering and fixing the right vocal cord arose from the cricoid cartilage (Fig. 10). Islands of cartilage and bone are found in about 30 per cent of enucleated tonsils. They are variously interpreted as arising from undifferentiated mesodermal cells, from embryonal cartilage rests and as products of inflammation.

Lipomas are attributed to misplaced groups of embryonic tissue cells or to a congenital tissue predisposition to their formation. Heriman's¹⁷ compilation from the literature included 25 lipomas in the pharynx and 15 in the larynx. Juracz¹⁸ collected nine additional cases of lipomas in the larynx. They were usually small and single, but Seifert's¹⁹ case was lobulated and of considerable size. A recent report by Faulder²⁰ includes two retropharyngeal lipomas, one of them 7 inches in length.

We wish to call attention to less known lesions. We would first describe a case presenting a very rare maldevelopment of the olfactory bulb. This condition was found in a 1-year-old child at an

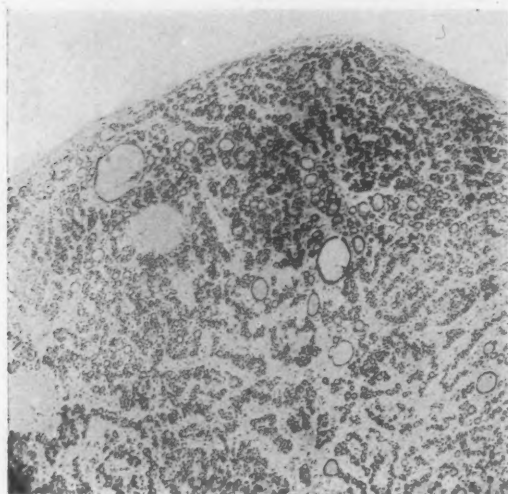


Fig. 8. Adenoma of thyroid at base of tongue. F-18.

autopsy performed by Dr. Klemperer²¹. In this instance there was total absence of the olfactory bulb, tract and trigonum olfactorius (Fig. 11). The sulcus olfactorius on both sides was identified; yet it extended only a short distance toward the frontal pole. The cribriform plate was perforated and a nodular cord was present at the left side of the crista galli with smaller cords in the right side. These are considered nerve cords coming from the olfactory mucous membrane but ending on the cribriform plate (Fig. 12). The ethmoid, nose and form of the head showed no abnormalities. Only one similar case is noted by Henke and Lubarsch²².

The relation of brain tissue to the nasopharynx is illustrated by two instances of meningocele within nasal polypi as reported by Guthrie and Dott²³ (1928). Clark²⁴ (1905) reports two gliomas in polyps of the nose, of congenital origin, and Rocher and Anglade²⁵ (1924) collected 11 cases from the literature and added cases of their own. Berger and Coutard (1926) report a polyp of the nose recurring five times after removal and finally identified as a glioma, or neuro-epithelioma. Berger had previously reported a similar case. We have included this type of tumor because it corresponds to the much more frequent glioma of the retina in which heredity seems to

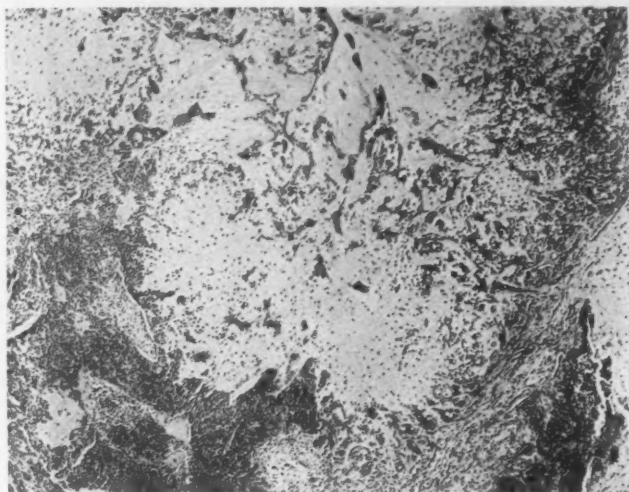


Fig. 9. Mixed tumor replacing the right tonsil. The mixture of cartilage, fibro-myxomatous tissue and epithelium is typical.

play so important a part. Portmann, Bonnard and Moreau²⁷ also found a neuroblastoma in the nasopharynx. It arose in the olfactory bulb.

We have reported a plexiform neuroma replacing the right tonsil, a "forme fruste" (von Recklinghausen) (Fig. 13). The occurrence of abnormal nerve tissue in the nasopharynx is considered in widely opposing views by different authors. Askanazy²⁸ (1914) studied a specimen from the nasopharynx 10 years before he decided to call it a nerve tumor. Berger²⁶, Guthrie and Dott²³ do not hesitate to express the opinion that many tumors of the nose and throat are doubtless of nervous origin.

Within the mouth of the very early human embryo important changes have taken place. From the roof of the primitive buccal cavity, or stomodeum, a narrow protrusion extends upward (Rathke's pouch) and unites with a downward projection from the forebrain. These fuse with an upward pocket from the foregut (Seesel's pocket) and form the pituitary body. Occasional cysts are found arising from the ducts still in communication with the pharynx. Accessory pituitary glandules are present in the lower animals and found occasionally in the pharyngeal connective tissue and in the pharyngeal mucous membrane (Erdheim²⁹). In man the entire pituitary gland



Fig. 10. Chondroma from larynx. Cartilage right and bone left centre with cartilage predominating. M-66 years.

has been found below the sella turcica, in the nasopharynx (Haberfeld³⁰). Pituitary tumors may arise in the nasopharynx but are very rare.

The notochord is a prominent structure in the young embryo. It is a cord of epithelial cells extending from the base of the brain to the sacrum. The bodies of the vertebrae are formed around it and its only remnants in the adult are found in the intervertebral discs. Tumors derived from the notochord may be cysts or solid growths. These growths are characterized by the presence of chorda cells. The typical chordoma cell is large, rounded and vacuolated and may

be distended with mucinous substance. Chordomas may occur in the nasopharynx. They are probably derived from notochord cells lying outside the developing vertebral bodies. These rests were formerly considered displaced embryonal cells, but Linck³¹ has shown that in the embryo they belong in definite places in the connective tissue. Klebs and Linck's reported cases of chordoma are well known. Lobell³² has collected 23 cases of chordomas of the nasopharynx and five more should be added to his list, especially the case reported by Syme and Cappell³³. A very recent report by Arzand and Clermont³⁴ describes a malignant chordoma (F-28) filling the nasopharynx with

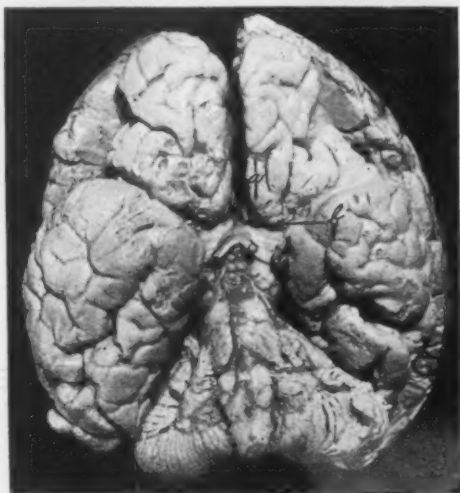


Fig. 11. Arhinencephaliabilateralis. Photograph of base of brain. Olfactor bulb, tract and trigonum absent. (a) Sulcus olfactorius, posterior third only. (b) Knob indicating olfactor tubercle. F-7 mcs.

its base near Luschka's duct. Malignant types grow very rapidly. Our own experience deals with one case only in this locality and the diagnosis in this case is still under consideration. It is a tumor of the nasopharynx extending to the cervical lymph nodes with rapid growth a striking feature of the tumor cells. Chordome cells may be confused with mucinous types of epithelial or cartilage cells (Fig. 14).

Melanotic tumors of the nasal cavities are rare, but authentic cases are on record. A true melanotic tumor is characterized by the presence of cells containing granules of melanin pigment, or chromatophores. They are found normally in the meninges, in the eye

and beneath the skin. The typical chromatophore is a large cell, elongated with one or more slender processes and possessing ameboid activity (Fig. 15). Many so-called melanomas proved to be tumors discolored by old blood pigment. These false melanotic tumors are usually benign and on that account there has been a mistaken general belief that the true nasal melanoma is also benign.

Typical malignant melano-epitheliomas arise in the nasopharynx. The most recent report is that of Heraux and Lemarié³⁵ (1926). A dark-colored polyp that was removed from the nose every six months for three years became suddenly highly malignant, with widespread

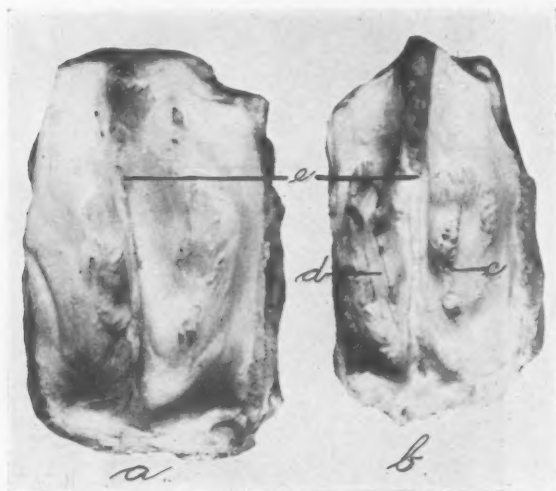


Fig. 12. Cribriform plates (a) normal. (b) XI above, (c) nodular nerve cord, (d) smaller nerve cords, (c) and (d) are covered by dura. (e) Crista galli.

metastases. Our only example of melanosis is in the tonsils, occurring in two cases, both benign (Fig. 12).

These melanotic tumors are included in our series because of the new light shed upon their origin by the brilliant work of Masson³⁶. Unna had said that pigmented naevi were modified epidermal cells. Soldan, in 1899, noted their frequent association with neurofibromatosis as in Recklinghausen's disease. Masson has gone into the finer details with noteworthy results. Masson's theory is the following: Sensory fibres from the central nervous system normally meet terminal sensory cells in or near the epidermis. When this

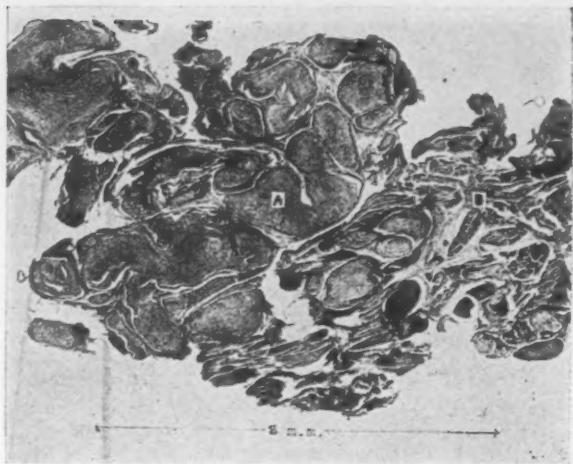


Fig. 13. Plexiform neuroma occupying the site of the right faucial tonsil. (No tonsil on right side.) A-Nerve cords. F-14 years (Meeker).

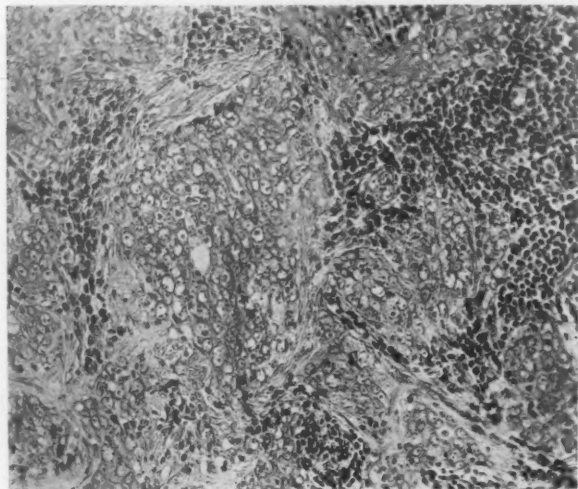


Fig. 14. Chordoma malignum ? (nasopharynx). Nests of large, clear cells, fibrous bands and dark-staining plasma cells.

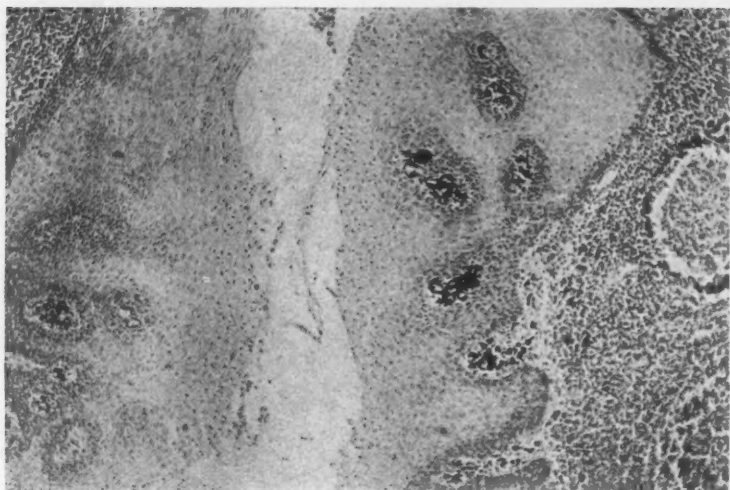


Fig. 15. Multiple pigmented nevi of tonsils. Melanin is black just beneath the epithelium. M-41 years (Meeker).

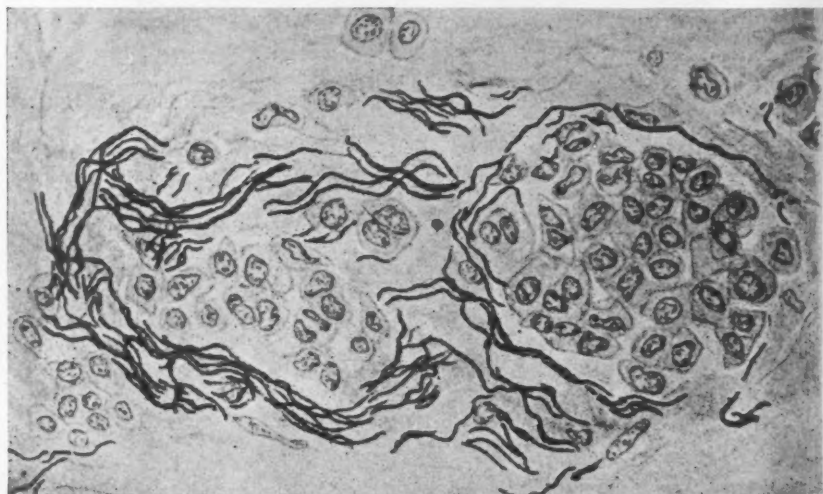


Fig. 16. Melanoma. Nerve fibrils among epithelioid nevus cells. Silver impregnation (after Masson).

fails to take place there occurs a proliferation of cells from both sources, something after the manner of an amputation neuroma and the epidermal cells may develop more or less pigment (Fig. 13). Earlier authorities, as Ribbert, believed that the chromatophores of the mesoblast give rise to the pigmented tumors. The history of metastases in all melanomas is in line with the migratory habits of these cells, whether mesoblastic or epidermal in origin. This wandering habit is one of distant heredity.

SUMMARY.

These cases demonstrate the relation of embryology to tumors of the nose and throat.

We have described tumors, such as cysts derived from persistent clefts, tumors from embryonal cell rests and those arising from mal-development.

Heredity plays an undoubted part in several types and a biological relation to distant stages of evolution is undoubtedly present in others.

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END-RESULTS IN FOUR TYPES OF NASAL NEOPLASMS. CASE REPORTS.*

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New York.

Case 1: Sarcoma Right Ethmoid, Antrum and Nasopharynx clinically cured six years after operation, and radium treatment.

C. B., age 24 years, a mechanic, was admitted to the New York Post-Graduate Hospital on March 27, 1922, with a right nasal obstruction and a bloody discharge. He also complained of a failing vision in the right eye. He had lost 15 pounds in weight. His father had died of pulmonary tuberculosis at the age of 35, and his mother of appendicitis at 26. One sister was living and well.

The patient had the usual diseases of childhood, and influenza in 1919. In May, 1921, he went to the Manhattan Eye, Ear and Throat Hospital because of nasal obstruction. An operation for nasal polypi and deviation of the septum was attempted but not completed because of profuse hemorrhage from a peculiar growth which was found in the right side of the nose. The blood Wassermann was 2+ and 0.3 m.gm. neosalvarsan was given and one dose of mercury. He remained four days in the hospital and did not return to the follow-up clinic of that institution, but nine months later reported to the New York Post-Graduate Hospital. The patient denied lues, but admitted having had gonorrhea. Both the blood Wassermann and the spinal fluid were negative. The sight in the right eye had been growing progressively worse for the past six months. The eye was somewhat proptosed and he could count fingers at three feet, while in the left eye the vision was 20/50. A soft mass, which bled easily, filled the right nasal cavity and involved the wall of the nasopharynx. A discharge of pus was also present. The septum was markedly deviated to the left. The throat was negative.

On April 3, 1922, an operation was performed by Dr. MacPherson, who made an incision of the mucous membrane of the right alveolar process. The antrum was opened. The nasomaxillary bone was removed. An external incision was made from the lip alongside of nose to infraorbital ridge, and over malar bone, the growth was removed; an iodoform drain for the antrum was placed through the

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nose. The external incision was closed with black silk. There had been so much bleeding that an infusion was made on the operating table. A report of the examination of the tissue (20828-11970) by Dr. Ward J. MacNeal is as follows: "The specimen is irregular in shape and measures 60x43x27 m.m. On section it is moderately firm and resilient, almost homogeneous in structure and appears to be made up of connective tissue throughout. Microscopic: Sections do

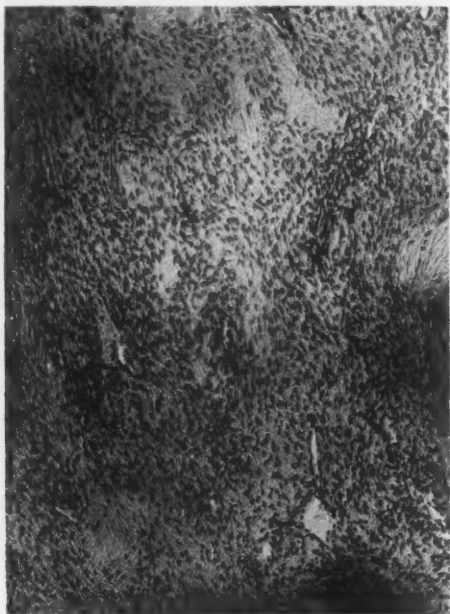


Fig. 1. Microphotograph showing fibro-sarcoma.

not include any epithelial covering. They present a structure of fibrous tissue in which there are moderately numerous blood vessels. In some places there are bundles of hyaline fibrous tissue surrounded by highly cellular matrix of more recent development. The cellular tissue is usually adjacent to blood vessels. In some places the tissue is edematous and there are occasional extravasations of blood. One finds only a few highly cellular areas but in these mitotic figures are found without difficulty. Diagnosis: Fibrosarcoma. Local recurrence should be expected." (Fig. 1.)

There was a stormy convalescence for two weeks, in which the temperature ranged from 101° to 105° F. and the pulse rate, 90 to 120. The patient was discharged on May 9th, but was readmitted on May 31, with a large growth filling the posterior right nares, together with a purulent discharge and severe pain in the right side of the face. Nine radium applications were given from June 1, 1922, to April 1, 1923, in which radium needles were implanted into the growth for a total of 350 m.gm. hours and external radium packs for 15,000 m.gm. hours. The patient has remained well, although an examination in December, 1928, revealed a bluish ovoid mass present in the ethmoid area. A section was taken for microscopical examination but showed chronic hypertrophic inflammatory tissue with no evidence of malignancy.

Case 2: Carcinoma of Right Ethmoid, Antrum and Sphenoid Sinuses, clinically well two years after operation, and radium therapy.

Max B., age 57 years, was admitted to the Post-Graduate Hospital, Feb. 15, 1927, with a swelling over the right superior maxilla. The condition began in July, 1926, as a swelling in the right cheek, which became progressively worse. There was no tenderness, pain, headaches, nor loss of weight. A moderate mucopurulent discharge was present on the right side of the nose.

The family history was negative for tuberculosis and malignancy. His previous illnesses were not significant. The blood Wassermann was negative. Roentgen examination of the sinuses by Dr. F. M. Law was as follows: "The frontals are large and deep, with a thin anterior wall, and a deep anteroposterior diameter in the floor. The left is clear. The right shows a mild involvement from thickened membrane. The anterior border of the ethmoid capsule is well back. The ethmoids consist of large cells. The left are clear. The right show a mild involvement from thickened membrane. Both antra are large. The floor is below the floor of the nose. The left is clear. The right shows a severe involvement from dense granulations and exudate. The sphenoids are large, and show a mild involvement from thickened membrane, and some swelling of the periosteum. There seems to be no necrosis of the alveolar process. The inferior orbital margin seems clear." (Fig. 2.)

A modified Caldwell-Luc operation was done, removing the anterior wall of the antrum, the internal wall of the right side of the nose. The ethmoid cells, part of the orbital floor and the anterior wall of the sphenoid was removed through an external excision.

The pathologist's report on the examination of the tissue is as follows: Gross: Estimated 30 c.c.m. of small, irregular, friable, light

gray and reddish masses of tissue, some of which contains thin pieces of bone. Microscopic: One section shows a polypoid swelling of the nasal mucous membrane with dilatation of the glands, fibrous increase and edema, as well as scattered infiltration of lymphocytes, plasma cells and eosinophils. The other sections, however, exhibit rapidly growing, infiltrating epithelial tumor composed of convoluted and

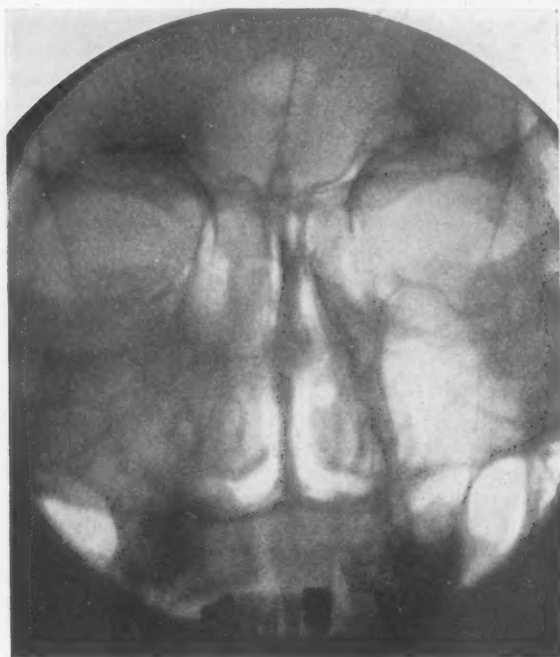


Fig. 2. Roentgenogram of nasal sinuses.

alveolar masses of rather deeply stained cells, usually spindle-shaped and exhibiting no indication of cornification. There is moderate amount of stroma infiltrated with lymphoid cells and eosinophils. Necrosis is a conspicuous feature in some parts. Diagnosis: Carcinoma, so-called squamous celled type of nasal mucous membrane." (Signed) Ward H. Cook (7334/29911). (Fig. 3.) Slides were studied by Drs. James Ewing, Ward J. MacNeal and L. H. Meeker, all of whom concurred in the diagnosis.

A culture of the pus from the maxillary abscess showed a streptococcus hemolyticus, staphylococcus albus and many diphtheroids.

One week after the operation the first radium treatment was given which consisted of a 30 m.gm. tube applied to the right ethmoid area and a 50 m.gm. tube applied in the right antrum for 21 hours. The total radium dosage has been 4,000 m.gm. hours in radium tubes applied in the ethmoid and antral cavities, and 9,000 m.gm. hours as external radium packs. On Oct. 7, 1927, on reopening the antrum under the canine fossa for further administration of radium, tissue was taken for study. The pathologist's report is as follows (44918/

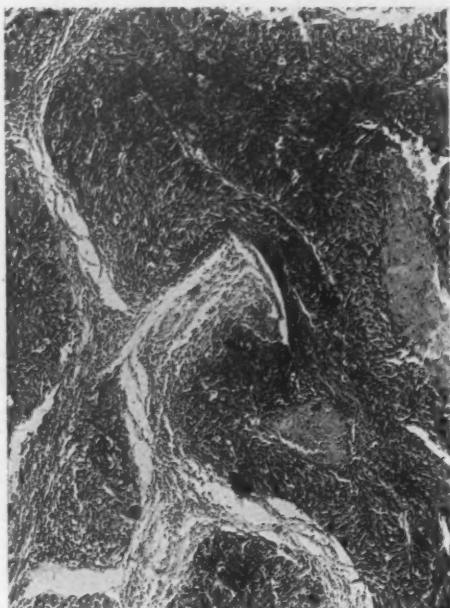


Fig. 3. Microphotograph showing squamous cell epidermoid carcinoma of antrum.

32880): Gross: There are three pieces of fibrous tissue measuring, respectively, 7x5x3 m.m., 6x4x2 m.m., 5x4x2 m.m. These are very dense, almost cartilaginous in consistency. Microscopic: Sections of the soft parts show chiefly fibrous tissue. The fibrous tissue is dense and hyaline and there is mild inflammatory reaction about the blood vessels. One piece presents a different picture. It is covered with pseudo stratified columnar epithelium over several small areas, a granulation tissue extends between these areas. The granulation

tissue is partly necrotic and overrun with lymphocytes, plasma cells and polynuclear leukocytes. Several spicules of necrotic bone are embedded in the fibrous tissue. There is no evidence of the previous carcinoma in the pieces under examination. Diagnosis: Chronic productive inflammation with areas of granulation tissue." (Signed) Dr. L. H. Meeker.

On Oct. 2, 1928, on removal of a right nasal bone because of necrosis, further tissue was removed from the ethmoid area. The pathological report is as follows: "Gross: There are 15 small pieces measuring together 12x12x8 m.m. They are irregular pieces of yellow-gray tissue composed of soft tissue and bony fragments.



Fig. 4. Papillary squamous cell carcinoma of external nose.

Fig. 5. Scab formation of tumor mass which has undergone liquefaction.

Microscopic: After decalcification the sections show necrosis in part, but there are viable portions. In the viable bony tissue the marrow spaces are filled with fibrous tissue, infiltrated by lymphocytes and plasma cells. There are also irregular lumina filled with necrotic cells, the nature of which is not evident. The soft tissue attached to the bone is dense fibrous tissue infiltrated with lymphocytes and plasma cells but nowhere are there any epithelial cells. Diagnosis: Necrotic bone and viable bone showing chronic inflammation. No carcinoma." Tonight, Jan. 23, 1929, there is no indication of recurrence but we are not reporting this case as a cure, clear as the operative field appears, and we hope to report the later developments.

Case 3: Extensive Epidermoid Carcinoma of Nose Treated by Radium.

John D., age 71 years, reported March 17, 1922, with a large ulcerated growth of the nose, which gave no symptoms other than obstruction to his line of vision. The condition began several years before as a small, warty growth on the tip of the nose.

Examination revealed an irregular, nodular, ulcerated growth involving the greater part of the external nose (Fig. 4). A clinical diagnosis of epithelioma was made and pathological report showed the lesion to be the squamous celled type. The radium treatments were as follows: March 17, 1922, 10 radium needles having a total content of 82.5 m.gm. were implanted into base of the growth for two hours. April 9, 1922, four needles, each containing 7.5 m.gm., were inserted into the growth for two hours. April 25, 1922, four needles of 5.0 m.gm. were applied for three hours. May 19, 1922, four radium needles containing a total of 27.5 m.gm. were inserted into the growth for two hours. Aug. 18, 1922, a 25 m.gm. unscreened plaque was applied for one-half hour to each of three spaces. Nov. 17, 1922, the 25 m.gm. plaque was applied for one-half hour to each of two spaces. Six weeks after the first application of radium, the growth had diminished in size and the result of the treatment showed a huge scab formation at the end of the nose (Fig. 5).

The end-result is a smooth, fibrous connective tissue replacing the original growth. A good cosmetic result has been obtained, which no other form of treatment would seem to equal (Fig. 6).

Case 4: Rhinoscleroma.

Ida S., age 26 years, a Russian by birth, a patient of Dr. Fred S. Lovell, was referred for radium treatment, Feb. 15, 1922. For several years she had gradually developed nasal obstruction. At the time of admission to the Post-Graduate Hospital in 1918 the entire left nares was obstructed with a diffuse, thickened and nodular growth, and to a lesser degree in the right side. Tissue examination revealed typical rhinoscleroma. Four X-ray treatments of moderate intensity were given in 1918, one in 1919, one in 1921. There was a relief of the nasal obstruction, but several irregular hard nodules covered the floor of the left side of the nose and involved the inferior turbinate.

The radium treatments consisted of inserting 5 m.gm. platinum needles in the base of the rhinoscleroma nodules for three hours. On Nov. 20, 1924, the following progress note was received from Dr. Lovell: "Wonderful improvement in Miss Ida S. case. Did I

not know what she had formerly I would say a perfect condition, but if you will press the alae together you will find the left one close to the lip is slightly thickened. Inside, the nostrils seem perfectly healthy. I would advise another application close to the lip and I would like to see her again in two months."

The final radium treatment was given Dec. 16, 1924, and consisted of the application of a 50m.gm. tube in the left nares for two hours. On Oct. 16, 1926, Dr. Lovell writes as follows: "You may be interested to know that Miss Ida S., whom you treated for rhinoscleroma with radium, was at my office today, and shows no signs of the disease. The site of the growth inside the left nostril and alae and extending backward onto the inferior turbinate shows no remaining



Fig. 6. End-result of treatment showing fibrous connective tissue replacing growth.

scar. I think there is an absolute cure in her case." The patient is shown here this evening and shows no evidence of rhinoscleroma.

Rhinoscleroma is a chronic inflammatory condition produced by Frisch's bacillus, which gradually causes obstruction of the upper air passages. The action of radium in this condition is to produce dense fibrous tissue, replacing the loose granulation fibrillar meshwork in the submucosa. In early cases radium offers a good chance for a cure, and in the advanced cases palliative relief is obtained. In three early cases with the disease localized to the nasal cavities there has been a clinical disappearance of the neoplasm. In three advanced cases the nasal obstruction was relieved for from two to four years.

120 E. 75th Street.

**CASE REPORT: CHRONIC EMPYEMA OF MAXILLARY
SINUS COMPLICATED BY ACUTE MASTOIDITIS
OF THE SAME SIDE.***

DR. ORAM R. KLINE, Camden, N. J.

The extension of nasal accessory sinus disease to the Eustachian tube and middle ear is not unusual. In fact, the frequency with which it occurs, especially when the seat of disease is in the maxillary sinus, prompted the report of this case.

History: W. H., colored, age 50 years, reported to the Nose and Throat Out-Patient Department of the Pennsylvania Hospital Oct. 4, 1927. He complained of having a "cold in head" for the past six months. His chief symptoms were a dull feeling over the right eye and a profuse discharge from the right nostril.

Examination: Ears: Negative. Both eardrums normal, hearing normal. Never had any ear trouble. Nose: Irregular nasal septum in contact with right middle turbinate. No signs of inflammation noted on left side. The right inferior turbinate and floor of nose bathed in greenish pus flowing from underneath the middle turbinate. Transillumination gave no information. The frontals and antrums of both sides failed to transmit light. The right antrum was irrigated by needle puncture underneath inferior turbinate and 2 or 3 drams of green foul-swelling pus washed out. The right nostril was now examined and no pus found. Mouth and throat: Teeth in fair condition. Tonsils moderate size, some injection of anterior pillars, no pus expressed. Some greenish pus noted on posterior pharyngeal wall. Redness and thickening of right pharyngeal wall.

A culture of the pus from the antrum was taken and later reported as hemolytic streptococcus and staphylococcus albus. The patient was referred to Dental Department, where right upper second molar was reported abscessed and extracted.

X-ray Report: The shadow of the right antrum is slightly more clouded than the left. This is not sufficient to warrant a diagnosis. The antrum was irrigated every three or four days for the next six weeks. The amount of pus was greatly decreased and the foul odor almost lost, but otherwise the character remained the same. A Caldwell-Luc operation was advised, but the patient wanted to remain at work.

*Read before the Philadelphia Laryngological Society, Jan. 9, 1929.

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Nov. 22 a large opening into antrum was made underneath the inferior turbinate. Since no polypoid masses were noted in the sinus, it was thought that a cure might be brought about by this procedure.

Nov. 26: Patient reported considerable improvement. Only a small amount of blood-tinged pus and mucus returned when the antrum was washed out through window underneath inferior turbinate.

Dec. 1: Today gives history of contracting a "cold" during the past week. Has had severe pain over right eye and in right ear. The ear began discharging last night. There is tenderness over frontal sinus and over tip of mastoid. Profuse discharge of thick pus from right nostril and thin yellowish pus from right ear. Temperature 100°. Advised to go to bed with ice bag to mastoid and frequent boric acid irrigations of ear.

Dec. 3: Right ear still discharging. Tenderness over mastoid improved. Thinks pain much better, but still quite severe at times when discharge from ear seems to stop. Eardrum was freely incised to increase drainage and antrum irrigated. Temperature 100°.

Dec. 6: Admitted to the House for treatment and observation. Profuse discharge from right ear. Slight tenderness over mastoid tip. Pus on floor of right nostril and underneath right middle turbinate. Lungs, heart and abdomen negative. Urine: Alkaline; specific gravity, 1,020; no albumin, no sugar. Blood counts: Dec. 8, hgb., 13 m.g. per 100 c.c.; W.B.C., 14,650; polys., 76 per cent; lymph., 19 per cent. Dec. 14, hgb., 13 m.g. per 100 c.c.; W.B.C., 9,600; polys., 63 per cent; lymph., 31 per cent.

X-rays (Dec. 6): The right mastoid cell area is sclerotic, with only a few cells in the extreme upper and lower portions remaining. The left, by comparison, shows a greater number of cells which are quite lacking in brilliancy of outline. Dec. 14: No change in X-ray findings.

The temperature for the first few days ranged from 99° to 101°, but later seldom over 100°. Smear from ear discharge showed many pus cells, Gram positive cocci (some in chains) and a few diphtheroid bacilli. The growth was a pure culture of hemolytic diphtheroid bacilli.

The above findings in addition to the fact that the patient was of an optimistic temperament, always reporting that he felt much better, influenced us in delaying operation.

The positive findings were tenderness over mastoid tip and mastoid emissary vein, no change in amount or character of discharge, no decrease in swelling within canal, and intermittent pain. Finally,

Dec. 17, a simple mastoidectomy was done under ether anesthesia. The cortex was very sclerotic and about one-fourth inch in thickness. Underneath this ivory-like cortex a large abscess cavity was found, with extensive bone destruction. In removing the diseased bone distinct abscesses were encountered over the lateral sinus, the facial nerve and the dura of the middle fossa. Definite twitches of right side of face occurred whenever granulations in facial groove were touched with the curette. The wound was packed with iodoform gauze and partially closed with silkworm gut sutures. The culture taken at operation was reported as hemolytic streptococcus.

The patient made an uneventful recovery, being discharged from the House, Jan. 1. There was no discharge from the canal following the operation.

Jan. 14: Wound completely healed. No dressing required. Hearing apparently normal. Jan. 26: Some pus still in right antrum. The opening made Nov. 22 was enlarged. The patient was given a cannula and instructed to irrigate through this opening daily with normal saline. The antrum infection now promptly cleared up. No found in nose or antrum at subsequent visits.

Testing of hearing with audiometer showed approximately 10 per cent loss of hearing for the spoken voice in the right ear.

Since streptococcus hemolyticus was the causative organism in both the chronic maxillary sinusitis and the acute mastoiditis, it is reasonable to assume that the mastoiditis was an extension of the antrum infection. Furthermore, if a radical antrum operation had been done when the patient first presented himself, the extensive mastoiditis and subsequent mastoidectomy might have been avoided.

414 Cooper Street.

PATHOLOGICAL LESIONS OF THE FRONTAL SINUS.*

DR. R. T. ATKINS, New York.

OSTEOMA OF FRONTAL SINUS.

R. L., male, age 54 years. Admitted to the hospital May 4, 1926.

Complaint: Marked prominence of the left eyeball; double vision; hard lump at the upper and inner angle of the left orbit.

Past History: Head injury eight years ago.

Present History: About one year before admission to the hospital the patient first noticed a slight prominence of the left eye and later a small lump appeared at the upper and inner angle of the left orbit. The eye gradually became more prominent, and the lump increased in size. There is no headache or pain, and the vision is fair. Recently the patient began to see double, and also complained of vertigo on bending forward.

Physical Examination: Eyes (Dr. R. G. Reese): The corrected vision is normal in each eye, both for distance and near. The exophthalmometer shows the left eye to be 4 m.m. more prominent than the right. There is limitation of motion of the left eye in all directions except downward. This limitation is more marked downward. Diplopia can be elicited with the red glass in all fields. A tumor is palpable in the left orbit up and in, and is hard, as if composed of bone.

Intranasal examination negative. General physical examination negative.

Clinical Laboratory: X-ray (Dr. G. S. Dixon): A large lobulated osteoma fills the frontal sinuses. One part of the mass, which is renal-shaped, measures 16x30 m.m. and gives the impression of having formed in an orbital recess of the left side. It appears to have lifted the roof and broken through below, into the upper and inner angle of the orbit. The other sinuses are apparently clear. Wassermann negative.

Pre-operative Diagnosis: Osteoma of the frontal sinus.

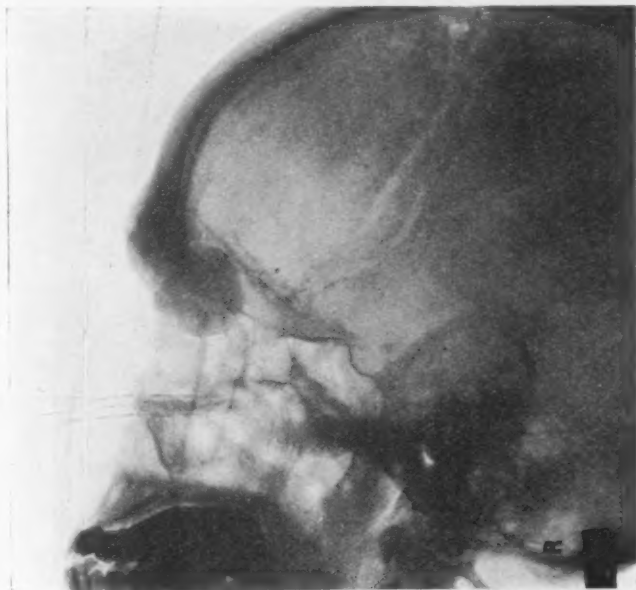
Operation: Winged incision, as is used in a bilateral radical frontal sinus operation. Anterior sinus wall removed, exposing bony tumor. The tumor was removed by taking away the surround-

*Read before New York Academy of Medicine, Section on Laryngology and Rhinology, Dec. 26, 1928.

Editor's Note: This ms. received in The Laryngoscope Office and accepted for publication Feb. 25, 1929.

ing bony tissue, until it could be rocked out en masse. The wound was closed with skin clips; rubber dam drainage.

Pathology: The anterior sinus wall was very thin and bulging forward. A hard bony tumor occupied the entire left frontal sinus, a portion of the anterior ethmoidal labyrinth, and there was an extension from the central mass into the orbit. The growth had eroded the bone over the ethmoidal region and orbit, where the dura was exposed ($\frac{1}{2} \times 1\frac{1}{2}$ inches in diameter). There was no evidence of infection present.



Osteoma of left frontal sinus.

Progress: Good recovery. The wound healed nicely, leaving a depressed scar.

FRONTAL LOBE ABSCESS.

J. G., male, age 17 years. Admitted to the hospital April 4, 1925.

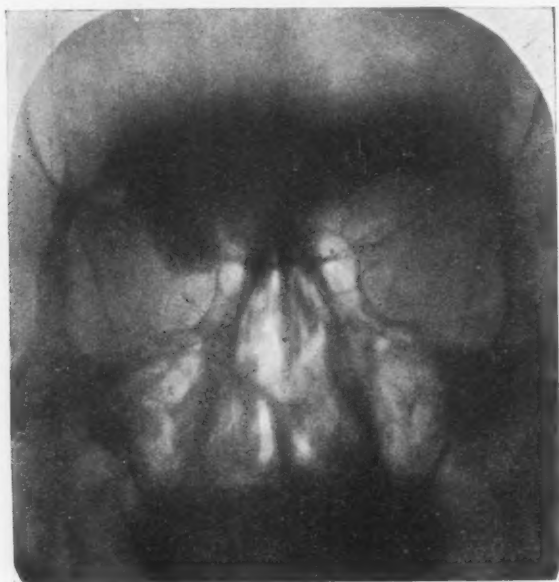
Complaint: Severe headache; protrusion of the left eye; swelling of the eyelids.

Past History: Frequent "colds". Has had sinuses treated.

Present History: Began two weeks before admission with a severe "cold in the head". Three days later sharp shooting pains through

the left eye and the left side of the head. One week before admission there was swelling of the soft parts about the eyes. He was admitted to the hospital with a diagnosis of orbital cellulitis.

Physical Examination: The left eye is pushed forward, downward and outward. Both lids are quite edematous, and there is marked chemosis of the bulbar conjunctiva. The eye movements are limited and there is diplopia in all fields, especially when looking down, indicating impairment of the superior oblique muscle. Fundus examination is negative. The right eye is negative.



Osteoma of left frontal sinus.

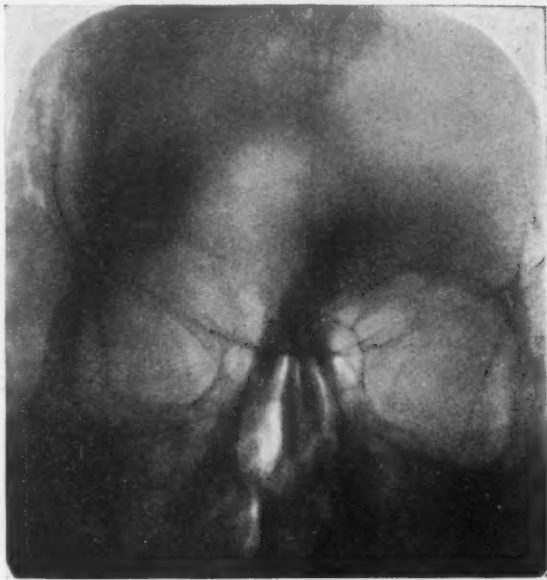
There is considerable pus in the left nasal fossa. The nasal mucous membrane is congested and the left middle turbinate is edematous. The left maxillary sinus is filled with pus. The throat is negative. The heart, lungs and abdomen are negative. Reflexes normal. Temperature 102° F., respirations 28, pulse 72.

Clinical Laboratory: X-ray shows cloudiness of all the sinuses on the left side. Smear of pus from the maxillary sinus shows long chain streptococci.

Preoperative Diagnosis: Suppurative pansinusitis; orbital cellulitis, left.

Operation: External ethmoidal incision through edematous soft parts. Necrotic inner orbital plate removed. Drain inserted into abscess cavity. This procedure was adopted so as to allow walling off of the acutely inflamed process before attempting more radical measures.

Pathology: Small quantity of foul-smelling pus in the orbit. Anterior ethmoidal cells are broken down and filled with pus of like character.



Post-operative appearance.

Progress: Dressing changed. Swelling of soft parts subsiding rapidly. Patient complains of headache. Fourth day post-operative, headache is very severe, temperature 104° F., the patient drowsy. There is some rigidity of the neck and a positive Kernig.

Killian operation; Coakley incision. Pus evacuated from frontal lobe abscess. Rubber tube drain inserted. Wound partially closed.

Pathology: Free foul-smelling pus in frontal sinus. Inner plate of frontal sinus necrotic and there is an abscess in the frontal lobe

communicating with the frontal sinus, containing about $\frac{1}{2}$ -ounce of foul-smelling pus.

Progress: Symptoms rapidly disappeared. Abscess ceased draining after three weeks and tube removed after one month. Patient was discharged six weeks following second operation, and has been entirely well since.



Showing necrotic area of inner wall of left frontal sinus.

OSTEOMYELITIS OF THE FRONTAL BONE.

P. G., female, age 36 years. Admitted to the hospital June 7, 1927.

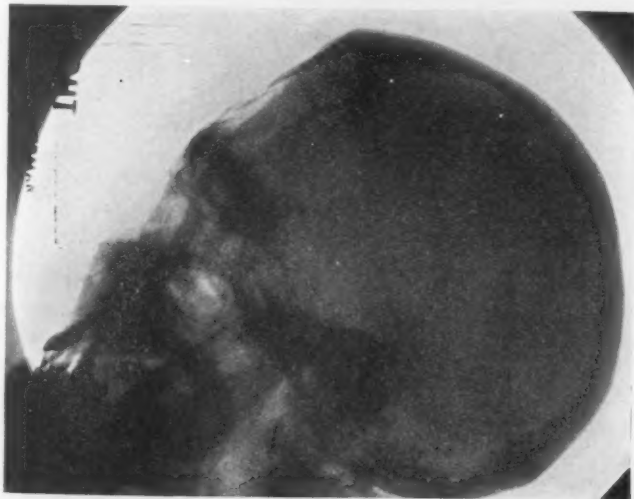
Complaint: Swelling of eyelids and forehead; severe frontal pain; profuse nasal discharge.

Past History: Frequent "colds" in head; nasal discharge; frontal headache.

Present History: Four months previous to admission to the hospital the patient developed a swelling of both upper eyelids and forehead, accompanied by severe frontal headache. An intranasal



Frontal sinusitis with epidural abscess. Preoperative appearance. Showing erosion of anterior and posterior walls of frontal sinus.



Osteomyelitis of frontal bone. Post-operative appearance.

operation was performed at another hospital without relief of the symptoms. The patient states that when she blows her nose the swelling over the forehead increases in size and feels full of air.

Physical Examination: Marked edematous swelling and tenderness of forehead and upper eyelids. Both nasal fossae filled with foul-smelling pus. Intense congestion of the nasal mucosa and edema of middle turbinates. Cocain and adrenalin fails to shrink the nasal mucosa.



Osteomyelitis of frontal bone. Post-operative appearance.

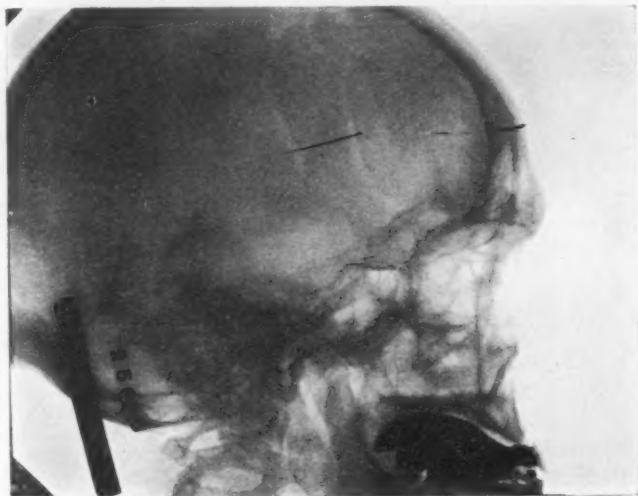
Because of the intense swelling of the lids, examination of the eyes is difficult, but there is no apparent proptosis. The pupils are equal and react to light.

Clinical Laboratory: Wassermann ++++. X-ray: Destructive osteoperiosteitis of the frontal bone extending from the supra-ciliary ridge for a distance of 7 c.m.

Pre-operative Diagnosis: Lues, chronic frontal sinusitis, osteomyelitis of the frontal bone.

Operation: Winged incision above eyebrows. It was necessary to make a vertical incision from glabella to hair line to expose all of diseased bone. Removal of diseased bone, and exposure of considerable dura. Ethmoidal incisions and removal of anterior ethmoidal cells. Wounds partially sutured; iodoform and rubber dam drainage.

Pathology: Considerable free foul-smelling pus under soft parts. Frontal sinuses small, filled with pus and necrotic granulations. Erosion of anterior and posterior walls. Thick, necrotic granulations covering large area of frontal dura. Ethmoidal cells necrotic and filled with necrotic granulations and foul-smelling pus.



Osteoma left frontal sinus. Post-operative appearance.

Progress: The patient was under treatment in the hospital for three months, during which time she received intensive antisyphilitic treatment. The wounds continued to drain profusely and the flaps failed to unite.

The discharge was foul-smelling, and culture produced no growth. There was considerable swelling of the upper eyelids and frontal flaps. The temperature varied from 99° to 101° , and there was a mild leukocytosis. Transfusions were given, but with very little beneficial effect.

At the end of three months the patient was given an anesthetic and two large sequestra were removed, which comprised a large portion of the remaining vertical plate of the frontal bone. Almost immediately the suppuration ceased and the wounds healed, with very extensive scar formation.

FRONTAL SINUSITIS WITH EPIDURAL ABSCESS.

D. G., female, age 36 years. Admitted to the hospital March 8, 1928.

Complaint: Swelling of eyelids and forehead, headache, fever, nasal discharge.



Osteoma—frontal sinus.

Past History: Frequent "colds in the head", accompanied by headache.

Present History: Ten days prior to admission the patient noticed a swelling of the right upper eyelid. The swelling spread to the lower lid and forehead. There was a profuse nasal discharge, fever and intense frontal headache.

Physical Examination: Marked edema of right eyelids. The eye is pushed downward and forward with limitation of movement in all directions. Considerable edema of the ocular conjunctiva. Marked edematous, tender swelling of the forehead above the right eye.

The right nasal fossa is filled with foul-smelling pus, which when removed appears to be coming from the middle meatus. The nasal mucosa is markedly congested. Temperature on admission, 103° F., pulse 120, respiration 20. General examination negative.

Clinical Laboratory: X-ray (Dr. G. S. Dixon): There is a large defect in the right frontal bone, extending beyond the middle line and downward to the orbital ridge. The left frontal sinus is cloudy. The ethmoids and antra are cloudy. Wassermann negative.

Pre-operative Diagnosis: Chronic frontal sinusitis, acute exacerbation.

Operation: Radical frontal sinus. Killian, Coakley incision. Wounds left open and packed.

Pathology: Considerable free pus under soft parts. Anterior wall of frontal sinus necrotic. Frontal sinus filled with foul-smelling pus and granulations. Large defect in the posterior wall of the frontal sinus due to erosion, exposing a large area of dura, which



Osteoma—frontal sinus.

was covered with thick granulations. Anterior ethmoidal cells necrotic and filled with pus and granulations.

Progress: The edematous swelling of the soft parts about the eye rapidly subsided, and the eye receded. There was considerable sero-purulent drainage from the wounds for about one month, and then the wounds closed except for a small sinus in the ethmoidal region.

X-ray examination failed to reveal the cause of this suppuration, so the wound was re-opened. A piece of rubber dam was found in the depth of the wound. The wound promptly closed after removal of the rubber dam. Patient now entirely well.

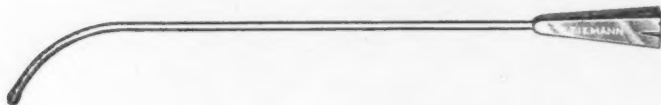
4 West 53rd Street.

NEW INSTRUMENTS—A NEW EUSTACHIAN CATHETER.*

DR. GEO. B. MCAULIFFE, New York.

Up to the present time no one has tried to change the shape of the Eustachian catheter. The present type has existed for over 50 years. It has a ring of varying size to show the direction of the tip and a funnel-shaped opening to accommodate the conical tip of the Politzer bag.

I have changed the funnel end to a pyramidal shape, the four sides of which give a firm resting place for the thumb and index and ring fingers. In place of the ring a notch is made on the surface which corresponds with the direction of the tip. The catheter is made of flexible metal. It is a mistake to use catheters which are rigid, because they must be constantly changed to suit the anatomical



variations of the nose and pharynx. The angle is never constant; it may be 145 (Poltzer, 130 or near 90 degrees. Therefore, one must have a catheter that is adaptable. I find in the majority of cases that a short bend and an angle approaching 100 degrees will give the best results.

There is nothing that gives an aurist a better hold on the confidence of his patient than an easy catheterization, especially when comparison is made of the procedure with that of other aurists who may have failed to find the tube quickly. It is surprising when patients relate that skilled aurists have had difficulty in catheterizing ears that offer very little trouble, and one wonders why it is so.

26 West 87th Street.

*Presented before the New York Academy of Medicine, Section of Otology, Feb. 9, 1929.

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International Digest of Current Otolaryngology.

Editor:

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Dr. D. E. Staunton Wishart, Toronto.

St. Louis Jewish Hospital E.N.T. Journal Club.

J. M. Smith, New York, in the April 3, 1929, issue of the Medical Journal and Record, New York, suggests a new operation for chronic purulent mastoiditis. His technique is to perform the usual simple mastoidectomy and then clean out and enlarge the antrum. He then enlarges the aditus by removal of some of the inner part of the bridge just external to the incus. This leaves the bony canal wall intact. He then separates the posterior half of the membranous canal wall from its bony attachment and holds it in place against the anterior canal wall. Through this opening he is able to thoroughly clean out the aditus, the middle ear cavity and the attic. The posterior membranous canal wall is then replaced and the middle ear allowed to dermatize while the posterior wound heals with healthy granulation tissue.

FINEBERG, St. Louis.

Ramsey and Pearce, in the British Medical Journal, March 23, 1929, report on the investigations of tonsil diseases by puncture of the tonsil. They base their results namely on bacteriological findings. They advance the possibilities of this method as being of use in the study of the relationship of puerperal sepsis and of rheumatic carditis in children.

FINEBERG, St. Louis.

Searcy, of Tuscaloosa, Ala., suggests the use of an oily solution for use in the nasal sinuses. He used an oily solution, containing menthol and camphor and diluted them with sterile liquid petrolatum. He has recently decided that chlorotone inhalant, diluted with liquid petrolatum, is more efficacious. The advantages claimed are that the natural openings remain patent longer and that the oil is retained by the mucous membrane for a longer time. In foul smelling conditions, half-strength chlorotone inhalant is sometimes used but usually one part of chlorotone and three parts of liquid petrolatum is best. Another advantage claimed with the use of this oil is that the patient

can breathe more freely through that side of the nose and that the action of the camphor and menthol lasts for many hours.

The author also believes that fewer washings are necessary and that fewer cases have to be operated on than when water is used. The solution is also of use in post-operative cases.

H. B. S., *Tuscaloosa.*

Kaiser, of Rochester, N. Y., in the *American Journal of Diseases of Children*, March, 1929, reports a study of the relationship of tonsils to acute rheumatic affections during childhood. In 439 rheumatic children, he found that the maximum susceptibility for the first attack was between the eighth and fourteenth year. The ratio of presence of tonsils was two to one in cases of first attack. Recurrence was 10 per cent less in cases that had had a tonsillectomy after the first attack than in those who had not had tonsillectomy. Kaiser believes that carditis was not influenced by tonsillectomy. The incidence of chorea was also the same in those who did and those who did not have tonsillectomy, but the association of chorea and carditis was less in cases that had had tonsillectomy after the first attack. He concludes that tonsillectomy should be performed in the rheumatic and in the potentially rheumatic child.

FINEBERG, *St. Louis.*

Hans Brunner, of Vienna, in the February, 1929, *Monatsschrift für Ohrenheilkunde und Laryngo-Rhinologie*, reports in a very lengthy article the results of experimental work on the iron pigment of the tonsil. He goes on the basis that the function of the tonsil is somewhat similar to that of the spleen and liver, in that they must have something to do with metabolism. Among his conclusions may be enumerated: (1) The iron content of the tonsil is normally very slight; (2) iron is found in the tonsil in typical spots, particularly in the border between the lymphatic tissue and the capsule; (3) iron-free pigment is found in exactly the same location; (4) iron and pigment deposits may be traced back to the resorption of tonsillar hemorrhage or to hemolytic changes or from the resorption of iron from the circulation; (5) the endothelial elements of the tonsil are impermeable to iron and because of this he differentiates the tonsil from the ordinary lymph gland.

FINEBERG, *St. Louis.*

Heindl, Sr., of Vienna, in the February, 1929, *Monatsschrift für Ohrenheilkunde und Laryngo-Rhinologie*, reports on a method of increasing the resistance against cocaine intoxication. He gives .3 to .5 grams of sodium veronal one-half an hour before operation (oral-

ly). He has had a preparation made by the I. G. Company in Leverkusen, which is called Paranoval. This seems to give him maximum results. Experimentally, Heindl was able to prove, on animals, and also in human beings, that by such treatment the resistance to cocain may be increased as much as 400 per cent.

FINEBERG, *St. Louis.*

G. Pichler, of Vienna, in the February, 1929, *Monatsschrift fur Ohrenheilkunde und Laryngo-Rhinologie*, reports the second part of his experimental work in the study of retrobulbar neuritis of nasal origin. His work was done on rabbits and he injected not only dye and bacteria but also pathologically changed tissues into the various sinuses. He studied the effect of all the various mechanisms of connection between the sinuses and the eyes and he sums up with the following three conclusions: (1) he could not demonstrate any reflex working from the nasal sinuses to the pathways of the nerve sheathes of the eyes; (2) aseptic body elements are the barriers which much be broken down to find the connection between the sinuses and the eyes; (3) the action of the eye, in infected sinuses, must be studied on a very great number of patients and additional scientific experiments performed before one may hope to definitely establish what the relationship is.

FINEBERG, *St. Louis.*

Bologolowow, of Leningrad, in the February, 1929 issue of *Monatsschrift fur Ohrenheilkunde und Laryngo-Rhinologie*, contributes a well worked out paper on the subject of rhinosurgical anatomy of the hypothysis. He first describes the methods of approach to the pituitary gland used by Eiselsberg, Partsch, Lowy, Hirsch, Cushing, Chiari, Denker and Lautenschlager.

He did numerous anatomical sections on cadavers and has studied the various kinds and positions of pituitary fossae that he might be likely to encounter. He anatomically divides the types found into seven. These are based on the actual space occupied by the sphenoid sinus in relationship to the density of the bone surrounding it. He shows very clearly the dangers that may be encountered by an atypically located pituitary fossa when it is associated with a shallow sphenoid. In other words, after boring through the sphenoid and going directly backwards, he shows how easy it might be to completely miss the pituitary and find oneself in the medulla. He advances the opinion that the most reliable landmarks are the tori (sellae, nervous optici and caroticus). He does not agree that the nasal septum should be used for orientation as to the midline.

FINEBERG, *St. Louis.*

Bondarinko, in the January, 1929, *Otolaryngologia Slavica*, published an interesting article on the effect of nasal disease on gastric juice. He found he was able to classify his results into two groups: (1) The Ozena group, in whom 52½ per cent had abnormal gastric juice, especially a diminution of acidity; (2) Chronic Catarrhal Sinusitis group, in which 63 per cent had abnormal gastric juice, especially an increase of acidity.

After treatment and clearing up of the sinus condition there was a rapid return to normal.

Cases with nasal obstruction also invariably showed an interference with gastric function producing a hyperacidity. The hypoacidity in Ozena is probably due to alkalidity of the swallowed crusts and phlegm.

PHILIP FRANK, *St. Louis.*

L. Hoffman, of Vienna, in the March, 1929, *Monatsschrift für Ohrenheilkunde und Laryngo-Rhinologie*, presents a very interesting article concerning pneumonic otitis in children and infants. He comments that the most frequent complication in pneumonia in children is otitis media and that it occurs in 92 per cent of cases of pneumonia in sucklings. He suggests that very often the otitis may be the dominating picture of the infection and the pulmonary lesion may be missed completely.

Hoffmann analyzes 1,008 cases of pneumonia in children up to 14 years of age (from the Von Pirquet Clinics, 1926-27). He found that in 275 cases of croupous pneumonia there was otitis media in 44 cases, in 29 of which the otitis was purulent.

In 179 cases of bronchial pneumonia there were 58 with otitis, of which 45 were purulent. In 50 cases of pneumonia associated with measles, there were 27 cases of otitis, all of which were purulent. In 92 cases of pneumonia associated with whooping cough, there were 20 with otitis, all of which were purulent. In 394 cases of pneumonia in sucklings, otitis occurred in 127, and of these, 103 were purulent. In 36 cases of pneumonia complicated by empyema, otitis occurred in 19, all of which were purulent.

Hoffmann very minutely studied these individual groups and deduces many interesting clinical thoughts.

FINEBERG, *St. Louis.*

